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STUDIES IN THE PHYSIOLOGY OF THE FUNGI

III. PHYSICAL PROPERTIES OF WOOD IN RELATION TO DECAY INDUCED BY LENZITES SAEPIARIA FRIES

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INTRODUCTION

Much interest has been manifested among the lumbermen and those associated in allied industries concerning specifications for structural timber. The classification of structural timber is based on strength and durability. Members of the Forest Service at the Forest Products Laboratory, Madison, Wisconsin, have shown that the true criterion of the strength of wood is its density (specific gravity), and that the percentage of summer wood indicates its density (Betts, '15).[1] But the physical properties of wood, which influence its durability, hitherto have presented an open question, and it is the purpose of this paper to report the investigations on this subject carried out by the author at the Graduate Laboratories of the Missouri Botanical Garden.

The experiments were conducted with three species of yellow pine, *Pinus palustris, P. echinata,* and *P. Taeda.* Special attention was given to the physical properties of each sample of wood used, data being secured on (1) resin content, (2) specific gravity, (3) percentage of summer wood (the dark portion of the annual growth ring) or proportion of summer wood to spring wood in the growth rings, (4) the width of the growth rings or number of rings per inch measured on a

[1] In a later paper the author will discuss the literature on the grading rules of structural timbers as they relate to strength, as well as the results of an experimental study of the relation between strength and durability of yellow pine timber.

radius of the stem, (5) sap- and heart-wood, and (6) the distance of the sample from the pith.

Susceptibility to decay and comparative resistance to fungous attack vary with the different species of wood, and it was believed that in any one species various qualities of the wood may influence its durability. Therefore, in the series of experiments reported below the three species of yellow pine were used, and a comparison of their relative resistance will be discussed. However, before describing the experiments and their results it will be necessary to consider the results of previous workers who have contributed to our knowledge of the influence of the physical properties of wood upon its durability.

Historical Review

Resin occurs widely distributed in the plant kingdom as a solid, semi-liquid, or dissolved in a resin solvent. It is most abundant in coniferous wood, where it exists in the sap-wood dissolved in terpenes or turpentine oils, and in the heart-wood as an amorphous solid or semi-liquid mass according to the degree of seasoning and age of the heart-wood. Various types and compositions of resin are found in many other groups of plants. Harz ('68) showed by analyses that it is to be found in the mycelium and fruiting bodies of *Polyporus officinalis* Fries, and more recently Malencovie ('07) has reported it in the mycelium and sporophores of *Lenzites saepiaria*. Resin has been generally considered a hindrance to the attack of wood-destroying fungi.

In discussing the inroads of the mycelium of *Trametes Pini* Fr., Hartig ('78) says that the terpenes and oils of turpentines are driven out of the wood in advance of the fungus, and the resin which is soluble in the terpenes is carried forward until it becomes so concentrated as to form a barrier or resistant wall, as it were. This is especially true in the sap-wood where resin exists in certain species of wood diluted in the terpenes. In the heart-wood where the resin is in a more or less solid condition it is difficult to conceive that it may be driven out by the entrance of the mycelium, yet the pressure

of the mycelium might result in an increased tension in the tissues, as may be the case in those forms of decay described by von Schrenk ('01, p. 204). Thus, coniferous trees should be pruned when young, at least before any heart-wood is formed, so that the resin will exude and cover the wound, since, as was demonstrated in a previous paper (Zeller, '16), fungi will not germinate nor grow on pure solid resin as it exudes from the wounded bark or sap-wood.

Hartig's observations, referred to above, were made in the field. He states that in the summer of 1877 damage done by wind gave opportunity to study the aseptic influence of resin on wounds. In all cases of fracture there was exudation from the sap-wood but not from the heart-wood. He further noticed that where resin in the solid state is infiltrated in the cell walls and also fills the cell lumen the penetration of the fungous mycelium is mechanically hindered.

Temme ('85) believed that certain kinds of wood are rendered more durable by a gum which is formed in wood exposed to air. This is especially true where active sap-wood is exposed as the result of a lesion. Bordering the active wood thus aërated a layer of "Schutzholz" is formed because of the infiltration of this gum, which, he believed, made the wood resistant to fungous attack.

Dudley ('87) observed that longleaf pine (*Pinus palustris*) does not seem to be exceptionally durable when placed in conditions favorable to the growth of fungi, as in roadbeds as railroad ties. He states that "ordinary specimens of this pine contain from 18 to 20 per cent of resinous matter, which is supposed to add much to the durability of the wood. But this does not seem to be the case when the wood is put in the ground or in the roadbed as ties."

To Mayr ('94) we are indebted, probably more than to any other worker, for our present knowledge of the influence of resin on the durability of coniferous woods. He has made an extensive study of the distribution of resin in these woody tissues and also of the physiological importance of the resin to the tree, besides drawing quite definite conclusions as to its influence on fungous growth.

Mayr distinguishes between the liquid resin, as it is found in the sap-wood of conifers, and solid resin, such as fossil amber. Fungi such as *Nectria* and *Pestalozzia* thrive on the soft resin, while the hard resin is very durable. Thus, the greater the amount of hard resin wood contains, the more durable will it be. He suggests that the influence of resin should not be overestimated, however, since other factors, such as density or specific gravity, dark color due to the impregnation with "Dauerstoff," climatic conditions under which the trees were grown, and the duration of seasoning, are of much greater importance in decay resistance. On the other hand, where different species of coniferous wood have the same specific gravity, Mayr ascribes the differences in durability to variations in resin content. Pieces of spruce, larch, and Douglas fir, for instance, often show the same specific gravity, but the spruce and larch are generally more durable than the Douglas fir, since the latter is considerably inferior in resin content.

Mayr further says that for the judging of the durability of all species of wood, the "Dauerstoff," a substance or substances which cause the dark color of heart-wood, must be taken into consideration; that is, that a species of wood possessing dark heart-wood surpasses in durability that with light-colored heart, providing the resin content and specific weights are the same.

The climatic conditions under which the trees are grown will influence the durability of the wood. Mayr suggests the pine as an example of this fact. For instance, the timber grown in relatively warm climates on sandy soils possesses a dark, broad heart, while that produced on gravelly soils in cooler climates has narrow, light-colored heart-wood, and under warmer conditions the wood is specifically heavier and possesses a greater resin content than in cooler regions.

It is also suggested in Mayr's conclusions that the seasoning of the wood influences the durability because of its effect on the resin content. If seasoning is rapid the resins may be carried out of the wood by the evaporation of the turpentine

and water, but, if slow, the hard resins are laid down within the wood, thus increasing durability.

We notice here that Mayr seems to lay as much stress upon specific gravity as a factor in the resistance of wood to fungous decay as he does on the resin content. Practically the same idea is conveyed by Falck ('09), who says that all three species of *Lenzites* (*L. saepiaria, L. abietina,* and *L. thermophila*) will attack pine sap-wood more readily than heart-wood, and coarse-grained or non-resinous sap-wood more readily than dense or resinous material. Pine heart-wood is attacked with difficulty, even by *Merulius lacrymans,* and hard, resinous knots, etc., are always immune.

Speaking of the decay of wood produced by *Lenzites saepiaria,* Spaulding ('11) suggests that resin is a factor in the resistance of southern pine. He states that "Whether it is able to rot the resinous heart-wood of the southern pines seems questionable. The writer has seen no instance where this has taken place, except in the outer layers of heart-wood which were not so completely filled with resin as the inner ones."

Hoxie strongly advocates resin as a criterion of the durability of pine wood. However, he has advisedly included in his specifications (Hoxie, '15) density (specific gravity of about .48), percentage of summer wood (33.3 per cent), and growth rings per inch as factors of importance. In 1914 he performed a very simple experiment from which he concluded that "resin is the important factor in the hard pines. . . . A block of longleaf pine 2 in. on a side, containing 18 per cent of resin, was sawed in two across the grain. Half of it was boiled in benzole and after the removal of the resin the benzole was driven off. Both pieces were cultivated in contact with wood containing living dry rot fungus. At the end of a year the specimens were dried and weighed. That from which the resin had been removed had lost 8 per cent in weight, the other only 2 per cent." This is in accordance with Mayr ('94), who has said that of two blocks having the same specific gravity, but the one resinous and the other not, the resinous will be the more resistant. However, when we consider the

variableness in weight of samples of the same species of wood the value of Hoxie's experiment may be questioned.

Hoxie's specification of "not less than 4 per cent resin" was based on "the percentage of resin in the sound centers of rotted beams taken from a mill." This resin content "was determined in order to get an idea of the amount required to stop fungous growth under ordinary mill conditions. In rotted beams of the poorest of hard pine there is generally a sound center which contains more resin than the remainder of the section. Sometimes it is not bounded by the growth rings but is very irregular, the cause being that resin has been irregularly deposited in the section owing to knots or injuries to the tree. The limits of the sound centers are frequently not the same as those of the heart-wood." In these cases Hoxie found that the limiting amount of resin which is just sufficient to stop the fungus is in the neighborhood of 3 per cent. Further, "*The limiting power of resin is undoubtedly not absolute* but varies with the moisture, variety of fungus and time of exposure. Therefore, it is safe to assume that a mill beam should have not less than 5 per cent of resin throughout successfully to withstand fungus under ordinary conditions of dampness and allowing a reasonable factor of safety."

While Hoxie has considered that the irregularity of the limits of the sound centers described above is due to the irregular distribution of resin, he has said nothing of the cracks in the beams due to seasoning. It has been the experience of the writer that fungous decay generally proceeds farther toward the pith of a timber along such seasonal cracks. This may also account for an irregular decay.

Another factor which Hoxie ('14) has considered is the relation of relative humidity of the air to fungous decay. He says: "Wood will become dryer or wetter in proportion to the relative humidity of the air; . . . Moreover, the susceptible varieties absorb moisture more rapidly than those which are more resistant to fungi."[1]

[1] Experiments to determine the optimum relative humidity of the air for the growth on, and the attack of, yellow pine wood by several wood-destroying fungi will be prepared by the writer. The relation of the relative humidity of the air to the absorbing power of various species of yellow pine will be a preliminary consideration.

In answer to an article by von Schrenk ('16) on the grading of yellow pine, Hoxie ('16) produces a plate showing the cross-sections of three planks of yellow pine heart-wood upon which *Merulius lacrymans* had grown for three years under identical, favorable conditions of moisture and temperature. The decay was greatest in that plank having the lowest specific gravity and at the same time the lowest resin content; and the plank having the highest specific gravity and the highest resin content was most resistant to decay. This is another example to substantiate the conclusions of Mayr ('94), cited above. Although Hoxie attributes the resistance of the heaviest plank to its resin content, it is impossible for the writer to draw the same conclusion, for this resistant plank, besides having the highest resin content of the three, had also a higher specific gravity and narrower growth rings than the other two planks.

Since the specific gravity of wood is to a more or less extent a function of the percentage of the summer wood (Johnson, '93, p. 27) contained, and since the density of wood and the breadth of the growth rings have been so closely related in the grading of coniferous timber, the limited literature dealing with these several properties of wood will be taken up as a whole.

Density has long been held as an index of the durability of wood. As early as 1818 McWilliams (1818, pp. 182–183) said that "from the experience of those most deserving of notice it appears that the durability of timber is in proportion to its solidity." He later defines "solidity" in the following manner: "When different sorts of timber are equally dry, the respective depths to which they will sink in water is a very good criterion of their proportionate solidity."

Mayr ('86), in a discussion of various species of pine, concludes that the wood which is heavier, although less resinous, is more valuable and durable. Later ('94) he has shown that the resin content does not markedly influence the specific weight of the wood, and he states that the more heavily lignified cell walls of the summer wood offer a mechanical resist-

ance to the growth of fungous mycelia, whether resinous or non-resinous.

Von Schrenk ('01), in connection with the description of the decay of *Robinia Pseudacacia* produced by *Fomes rimosus*, says: "The manner in which fungus hyphae spread through a piece of timber is determined to some extent by the structure of the timber. Wood which has large vessels, prominent medullary rays, resin channels, or the wood elements of which are large-lumened and thin-walled, will be penetrated throughout its entire mass more readily than wood where those natural channels are absent, or which has short, thick-walled elements. . . . Growth directly through a solid mass of wood rarely takes place, and when it does so it is a very slow process." Practically the same idea is conveyed by Buller ('06) and Bayliss ('08).

On the relative decay in summer wood and spring wood Falck ('09) says that in cultures of *Lenzites spp.* which attack coniferous wood, the culture blocks show spots of incipient decay in two or three months. These spots occur in the spring wood, and then with an increase of the incubation period may spread to the summer wood or may not, although the whole block is covered with the weft of mycelium. The spring wood is thus destroyed more readily than the summer wood. He noticed this especially in cultures on blocks of *Pinus sylvestris* where the summer wood appeared to be fully intact, while the layers of spring wood had become disintegrated and upon drying cracked into cubes (shown in his pl. IV, fig. 2). This same description of the decay and the relation of summer wood and spring wood to resistance to attack by *Lenzites saepiaria* is reported by Spaulding ('11, p. 21).

The idea previously held throughout the literature, and likewise the result of experience, has been that the sap-wood is more readily attacked by fungi than the heart-wood because of the richer store of available food material in the former. On the other hand, the relative durability of the sap-wood and heart-wood depends entirely upon the decay-producing organism and the species of wood attacked. For instance, some fungi will destroy the heart-wood and leave the sap-wood

practically untouched, while others may decay only the sap-wood, or both. Falck ('09) points out that *Lenzites abietina* and *L. thermophila* attack the sap-wood, while in cultures set up in the same, *L. saepiaria* will decay both the sap- and the heart-wood. Hartig ('02, p. 44) has shown that the sap-wood of *Pinus sylvestris* (Kiefernholz) is attacked by *Merulius lacrymans* more readily than the heart-wood, while the heart-wood of *Picea excelsa* (Fichtenholz) is more readily decayed by the same organism than the sap-wood. These are striking examples of the specificity of certain organisms, and indicate how the chance of infection of wood may vary with circumstances.

Hoxie ('15, p. 60) has taken these results obtained by Hartig, and on the basis of average resin analyses made by Mayr ('94) has concluded that this difference of resistance in the two species of wood is due to their resin content. However, since resin is so variable within the same species of wood, the analyses made by Mayr could hardly be considered compatible with decay experiments conducted by Hartig on different samples, although for the sake of argument there does seem to be a relation. This, nevertheless, could not apply to the resin in the sap-wood if we accept the results of Mayr ('94, p. 70), who shows that fungi thrive on resin in the liquid state as it is found in the sap-wood.

Humphrey ('16) has started a series of laboratory tests on the durability of American woods, the first of which reports the decay of various species of conifers induced by *Lentinus lepideus* Fr. Before the experiments were set up the test blocks were weighed, but no record was kept of their relative specific gravity, percentage of summer wood, resin content, etc. The test blocks were allowed to decay for intervals of 4, 6, and 12 months, and it is interesting to notice that after 12 months the sap-wood and heart-wood of longleaf pine were reduced in weight more than those of shortleaf. Humphrey says that "the specimen of longleaf pine, which did not appear very highly resinous, did not prove as resistant (51.1 per cent reduction) as shortleaf pine (20.7 per cent reduction), which was of a good grade." Since these tests are on one sam-

ple block of each species of wood and their relative densities are not reported, it is with considerable hesitation that we would compare thereby the relative resistance of the various species of wood tested. Nevertheless, in the case of longleaf and shortleaf pines it shows that in some cases, at least, shortleaf is more resistant than longleaf.

METHODS OF EXPERIMENTATION

Samples of wood of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) were secured from the Julius Seidel Lumber Co., St. Louis, and longleaf pine and loblolly pine (*P. Taeda*) from the John L. Roper Lumber Co., New Berne, N. C. The samples were numbered from 1 to 45. The cross-sections of 1–42 are shown in plates 10 and 11. Samples 1–11 and 43–45 were *P. echinata* from southern Missouri, 12–19 were *P. palustris* from Mississippi, 20–30 were *P. Taeda* from North Carolina, and 31–42 were *P. palustris* from North Carolina. The samples were selected in the lumber yards with only a cursory examination of the various physical factors to be investigated. In this way a wide range of these factors were obtained.

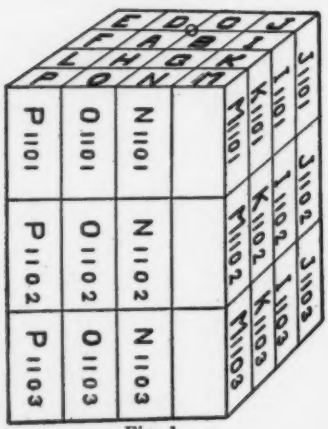


Fig. 1.

Each sample was cut into culture blocks 1×1×2 inches, as shown in fig. 1. First, the end of each of the samples was marked off into one-inch squares, and each of these squares was labeled with a letter, beginning alphabetically as near the pith as possible. (In fig. 1 the circle between A and C represents the pith.) With this system of lettering each letter represents a column of culture blocks a certain distance from the pith; thus, in the label M 1101, M represents the position of the column of culture blocks, 11 represents the number of the whole sample, and 1 the number of the first

block from the top in the column. Each culture block was labeled with a soft lead pencil, this proving to be the most satisfactory method of labeling.

After the culture blocks were sawed and labeled they were placed in an oven at 65° C. and dried to a constant weight and then weighed in grams, accurately to the second decimal, and estimated to the third. The period of time for kiln-drying to constant weight proved to vary according to the porosity of the wood, the lighter wood drying in 3 to 4 days, the heavier in 6 to 7 days.

After the weights were obtained, the volumes of the culture blocks were determined by immersion in mercury. A graduate cylinder calibrated to 2-cc. divisions was cut off, so that, when filled with mercury up to within 2.5 inches of the top, blocks could be inserted and removed with ease. This method is sufficiently accurate and practicable where a large quantity of volume determinations are to be made. Its main inaccuracy lies in the large surface of mercury exposed where the reading is taken. The volumes were taken in cubic centimeters. From the weight and volume obtained the specific gravity was determined for the individual culture blocks.

The percentage of summer wood was determined for each column of blocks in a sample by measuring in millimeters the width of the layers of summer wood on a radial line 2.5 cm. long and multiplying this value by four. These measurements were made on a smoothly planed cross-section of the whole sample. The values for percentage of summer wood cannot be considered absolute. It will be noticed that even within the individual columns of culture blocks the specific gravity may vary considerably. At first it was thought that this might be due to error in determining the specific gravity, but upon examination of the individual blocks it was found to be due to another cause. It is difficult while rip-sawing a sample to follow the grain of the wood exactly. Thus, whenever the lengthwise sawing is at all oblique to the grain, there is a change in the apportionment of summer wood for the neighboring blocks, changing the specific gravity proportionately.

The number of growth rings per inch were counted on the

same radial line as was used to determine the percentage of summer wood. The distance of the culture block from the pith was taken as the distance in inches from the center of the culture block to the pith. If the sample did not contain the pith the location of the latter was determined from the average curvature of the annual rings.

One resin analysis was made for each column of culture blocks, a block of an average specific gravity for the column being used. The samples to be analyzed for resin were kiln-dried at 65° C. until they reached constant weight. They were then removed to a desiccator to cool to room temperature, after which they were planed into fine shavings, which were stored in stoppered bottles until used. Five-gram quantities of shavings were used for each analysis. The shavings were placed in the upper chamber of a Soxhlet extraction apparatus which contained enough glass wool to prevent them from siphoning off when the chamber was emptied automatically. The solvent for extraction was benzol, and the extraction was continued for 36 hours for each sample. Small Westinghouse electric disc stoves of 1.8 amperage were used to keep a constant heat. After extraction the benzol containing the resin was distilled, and the resin transferred to a tared watch-glass, and the contents dried to constant weight in an electric oven kept at 60–65° C. The resin percentages given in table 1 are based on the total hard resin thus extracted and dried.

PREPARATION OF CULTURES

For cultures wide-mouthed jars of one quart capacity were used. In the bottom of each jar there was placed a ¾-inch layer of macerated paper, the well-known Scott's toweling being employed for this purpose. This paper had previously been soaked in distilled water for several hours to remove all readily soluble chemical compounds. After this it was squeezed out, then again rinsed in distilled water, and finally squeezed out until fairly dry before being placed in the jars. Upon this layer the blocks were placed on end, as can be seen in plate 9. The jars were plugged with cotton and sterilized.

STERILIZATION

The jars were sterilized in an autoclave for 45 minutes at 20 pounds pressure. Tests were conducted on sterilizing the cultures when they contained sufficient water for inoculation and when no water was added. It was found that some of those sterilized in a wet condition lost resin by steam distillation, and that the resin was not lost by sterilization if the blocks were dry and placed in a dry jar, although sterilized in steam in an autoclave. The loss of resin proved to occur when the blocks contained more than 17.6 per cent resin. There is a criticism, however, of any method of sterilization by heat when wood containing resin is concerned. Heat will necessarily rearrange the resin from the condition in which it naturally exists in wood. This is probably the greatest error in the present preliminary work along this line of investigation.

Tests on the effect of sterilization on the lignin elements were conducted. It was found that thin shavings of wood in water autoclaved for one hour were not delignified to such extent that by staining with zinc chloriodid any change could be detected, although the water in which the shavings had been boiled gave a very faint pink color with phloroglucin and hydrochloric acid. Potter ('04) believed that any method of sterilizing with heat considerably altered the lignin of wood. His tests were made on very young wood, however. Spaulding ('06) repeated Potter's tests and found that it takes 15 to 40 hours of sterilizing at 100° C. to effect any change in the wood elements.

INOCULATION

After the jars were sterilized the cultures were moistened by adding sterile distilled water, and then were inoculated with *Lenzites saepiaria*. In a previous paper methods of obtaining pure cultures and the propagation of the fungus on various media — Thaxter's potato-hard agar, pine sawdust, and blocks of pine wood — have been described in detail. Agar was found to be the best medium to employ in growing the fungus to be transferred to these block cultures. The fungus

produces oidia very readily on agar. Small fragments of the agar containing the fungous mycelium were transferred either to the tops or bases of the culture blocks and so placed that a nocule came in contact with each block. In the first inoculations, where the water was not yet wholly taken up by the blocks and paper, the nocules floated, and when the jars were moved the oidia were scattered; thus in a few days some blocks were covered with a mycelium, while in others the mycelium was merely growing out from the nocules. Therefore, the methods of inoculating were changed, the oidia being scattered over the surface of the blocks by agitating the water introduced into the jars immediately after inoculation.

The cultures were incubated for one year, a part of the time at room temperature and a part of the period in a very humid rotting-pit at a temperature varying from 22° C. in summer to 30–35° C. in winter when the steam heat could be utilized. The jars were watered from time to time so as to keep the paper beneath the culture blocks damp and the relative humidity of the air within the jars approximately 100 per cent.

In all experiments reported in this paper the criterion on which fungous decay is based is the loss in weight during incubation. Thus, when the culture blocks were removed from the jars after one year, they were placed in an oven at 65° C. and again dried to constant weight before final weighing. A control on loss of weight due to sterilizing was arranged. Twenty-five blocks were dried, weighed, and sterilized, and then again dried and weighed, but, as stated above, there was no loss in weight unless the percentage of resin was above 17.6 per cent.

Description of Culture Series

Four series of cultures were prepared, and they have been designated, respectively, series A, B, C, and D.

SERIES A

In series A culture blocks of longleaf pine (*Pinus palustris*), shortleaf pine (*P. echinata*), and loblolly pine (*P. Taeda*) were used in their natural conditions and placed in jars as

described above and inoculated with *Lenzites saepiaria.* Approximately 2500 culture blocks were prepared for this series, but the results given in table 1 are taken on 743 blocks of *P. palustris,* 594 blocks of *P. echinata,* and 321 blocks of *P. Taeda,* or a total of 1658. These were incubated for one year. Some of the remainder of the series were left in culture for a two-year period, while others were used in work to show the relation of the oxygen and water content of the substrate to the growth of *Lenzites saepiaria,* as previously reported (Zeller, '16). In the following table the resin percentage, percentage of summer wood, number of rings per inch, and distance from the pith are values for each lettered column of blocks in a sample. Whenever any of these factors are correlated with specific gravity or the percentage loss in weight, as in the plotted charts described below, the average values of the latter for any one lettered column are used.

TABLE I (Series A)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
A 101	29.	17.962	.620	17.959	.016	16.37	17.5	15.0	.75	.660	4.735
A 102	29.8	19.32	.648	18.095	6.34						
A 103	29.8	23.18	.778	20.501	11.59						
A 104	29.3	18.217	.621	17.455	4.18						
A 107	30.0	19.019	.633	18.725	1.55						
B 101	25.7	15.392	.600	14.998	2.56	23.3	10.0	10.0	.75	.620	2.51
B 102	26.1	16.149	.618	15.690	2.84						
B 103	26.3	16.684	.634	16.190	2.96						
B 105	26.5	16.496	.622	16.175	1.94						
B 106	26.3	16.502	.627	16.13	2.25						
C 101	29.0	19.042	.656	18.455	3.08	17.1	30.0	15.0	1.50	.678	3.06
C 104	30.0	20.155	.671	19.710	2.21						
C 105	29.5	20.150	.683	19.580	2.82						
C 106	28.5	19.717	.692	19.025	3.51						
C 107	28.9	19.948	.690	19.215	3.67						
D 101	27.5	17.490	.635	17.488	0.01	30.5	35.0	13.0	1.50	.671	3.88
D 102	27.5	18.130	.659	17.459	3.71						
D 103	27.7	18.854	.681	18.091	4.05						
D 104	27.6	18.153	.658	17.478	3.72						
D 105	27.9	18.652	.668	17.912	3.97						

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
D 106	27.9	18.926	.678	17.940	5.21						
D 107	26.9	19.378	.720	18.124	6.47						
E 101	28.5	22.730	.797	21.976	3.32	34.2	30.0	14.0	2.50	.902	7.728
E 102	30.0	25.690	.856	23.780	7.43						
E 103	31.4	29.123	.927	26.560	8.80						
E 104	32.0	30.867	.964	27.800	9.93						
E 105	31.9	30.801	.966	27.980	9.16						
F 101	29.0	18.116	.624	17.610	2.79	33.9	30.0	13.0	2.50	.682	5.97
F 102	30.3	19.187	.633	18.386	4.17						
F 103	31.4	20.094	.639	19.067	5.11						
F 104	31.0	20.590	.664	19.451	5.53						
F 105	31.9	23.118	.724	21.317	7.79						
F 106	31.2	25.187	.807	22.560	10.44						
G 101	27.0	18.456	.684	17.620	4.53	24.4	32.0	12.0	2.0	.710	3.73
G 102	27.0	18.671	.692	18.000	3.60						
G 103	27.0	19.189	.711	18.600	3.07						
G 104	26.5	19.160	.723	18.515	3.31						
G 105	27.9	20.618	.739	19.760	4.16						
H 101	26.5	24.931	.941	22.048	11.57	26.9	32.0	12.0	2.75	.838	8.45
H 103	26.8	22.285	.832	20.480	8.10						
H 104	26.0	20.874	.803	19.265	7.70						
H 105	26.0	20.206	.777	18.910	6.42						
A 203	31.5	13.708	.435	12.740	7.06	1.0	10.0	13.0	.75	.460	4.27
A 204	32.0	13.923	.435	13.390	3.82						
A 205	30.7	15.276	.497	14.755	3.42						
A 206	31.8	14.846	.467	14.800	.31						
A 207	31.8	14.196	.447	13.170	7.24						
A 208	31.9	15.325	.480	14.750	3.75						
B 207	35.0	14.768	.422	14.092	4.58	1.8	15.0	15.0	1.50	.423	4.67
B 208	33.5	14.179	.424	13.507	4.75						
C 201	29.7	13.705	.461	13.440	1.93	0.6	20.0	15.0	1.75	.461	3.07
C 202	29.5	13.650	.463	13.295	2.60						
C 203	31.5	14.609	.464	14.203	2.78						
C 204	31.2	14.564	.467	14.298	1.83						
C 207	29.7	13.480	.454	12.938	4.02						
C 208	28.0	12.828	.458	12.150	5.29						
D 201	30.0	13.782	.459	13.510	1.97	1.4	15.0	15.0	2.25	.455	1.70
D 202	30.0	13.580	.453	13.421	1.17						
D 203	31.2	14.132	.453	13.973	1.12						
D 204	32.0	14.719	.460	14.528	1.30						
D 207	30.5	14.034	.460	13.793	1.72						
D 208	31.0	13.935	.449	13.530	2.91						
E 203	30.0	13.187	.439	13.071	0.88	1.5	20.0	11.0	2.75	.442	2.17
E 204	31.0	13.569	.437	13.368	1.48						
E 205	31.8	14.093	.443	13.811	2.00						
E 206	31.3	13.986	.446	13.376	4.36						
E 207	31.5	13.791	.437	13.418	2.72						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Shortleaf pine (*Pinus echinata*)											
E 208	32.0	14.397	.450	14.171	1.57						
†F 203	30.1	13.680	.454	9.773	28.6	2.0	15.0	13.0	3.0	.455	12.04
†F 204	30.3	13.815	.456	12.867	6.86						
†F 205	30.2	13.731	.455	13.426	2.22						
†F 207	32.0	14.603	.457	13.064	10.5						
A 301	30.7	20.190	.657	19.520	3.32	4.8	16.0	15.5	1.0	.653	6.12
A 302	30.0	18.986	.633	17.841	6.03						
A 303	31.0	20.665	.666	19.070	7.71						
A 304	30.6	19.863	.649	18.814	5.28						
A 305	30.5	20.573	.674	18.900	8.14						
A 306	30.0	19.340	.645	17.804	7.95						
A 307	30.1	19.497	.647	18.639	4.41						
B 301	28.4	18.893	.665	18.492	2.12	2.8	16.0	18.0	0.75	.665	2.12
†C 301	29.7	20.630	.695	18.001	12.74	3.3	30.0	16.0	2.50	.705	11.73
†C 302	31.5	21.850	.694	19.529	10.61						
†C 303	30.0	20.884	.696	18.573	11.08						
†C 304	31.2	21.730	.696	19.611	10.21						
†C 305	30.5	21.930	.719	18.490	9.75						
†C 306	30.0	21.705	.724	18.987	12.51						
†C 307	30.0	21.421	.714	18.155	15.25						
†D 301	27.0	17.364	.643	14.525	16.3	2.5	30.0	17.0	1.75	.658	22.3
†D 302	27.5	17.940	.653	14.245	20.6						
†D 303	29.5	19.135	.648	13.115	31.4						
†D 304	29.0	19.086	.658	14.325	25.0						
†D 305	29.0	19.310	.666	15.105	21.8						
†D 306	28.0	18.965	.677	15.055	20.6						
†D 307	28.0	18.651	.666	14.853	20.4						
†E 301	27.2	18.830	.692	18.170	3.51	3.2	30.0	18.0	1.75	.686	5.69
†E 302	28.0	19.299	.689	18.109	6.16						
†E 303	29.5	19.980	.677	18.560	7.11						
†E 304	29.2	20.075	.688	18.453	8.09						
†E 305	29.0	19.825	.684	19.117	3.57						
*F 302	27.8	17.334	.623	14.299	17.51	2.1	30.0	20.0	2.25	.624	17.68
*F 303	28.0	17.610	.628	14.380	18.34						
*F 304	28.1	17.990	.640	14.616	18.75						
*F 305	27.9	18.034	.646	15.130	16.10						
A 401	31.5	21.232	.675	20.490	3.49	3.6	50.0	10.0	2.25	.691	3.69
A 402	30.5	21.035	.690	20.185	4.04						
A 403	30.5	21.280	.698	20.712	2.67						
A 404	30.5	21.270	.698	20.591	3.19						
A 405	30.7	21.283	.693	20.650	2.97						
A 406	30.0	20.786	.693	19.665	5.40						
A 407	30.0	20.784	.693	19.929	4.11						
B 401	29.0	19.519	.673	18.652	4.44	2.8	55.0	8.0	2.5	.688	5.15
B 402	28.5	19.617	.688	18.512	5.64						
B 403	30.7	21.150	.688	20.016	5.37						
B 404	30.0	20.165	.672	19.198	4.80						
B 405	30.2	20.930	.693	19.803	5.39						
B 406	30.5	21.280	.698	20.193	5.11						
B 407	31.0	21.838	.705	20.683	5.29						
C 403	29.5	21.520	.730	21.157	1.69	1.9	50.0	11.5	3.25	.719	7.38
C 404	30.5	20.161	.726	18.200	9.74						
C 405	29.2	19.131	.709	17.865	6.57						
C 406	29.8	20.091	.721	18.220	9.31						

* Sap-wood.
† Partially sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
C 407	30.5	20.295	.711	18.343	9.60						
D 401	32.0	20.71	.710	19.634	5.20	2.0	45.0	11.0	3.25	.702	5.63
D 402	31.5	21.415	.708	20.060	6.33						
D 403	31.2	20.199	.711	18.663	7.61						
D 404	31.5	21.662	.688	21.427	1.08						
D 405	31.0	19.470	.692	17.930	7.91						
E 401	31.0	22.465	.725	22.421	.196	3.55	35.0	10.5	3.5	.746	5.63
E 402	31.0	23.480	.757	22.000	6.30						
E 403	30.5	23.170	.760	21.460	7.39						
E 404	31.0	23.414	.755	22.000	6.04						
E 405	31.7	23.251	.733	21.340	8.21						
F 401	30.5	19.115	.627	18.410	3.69	2.0	60.0	5.0	4.0	.686	4.67
F 402	30.0	19.945	.665	18.830	5.58						
F 403	30.2	20.650	.684	19.645	4.84						
F 404	30.5	20.735	.679	19.760	4.71						
F 405	31.0	21.620	.698	20.730	4.12						
F 406	30.7	22.030	.718	21.060	4.40						
F 407	31.0	22.799	.735	21.610	5.21						
† A 501	30.0	15.216	.507	14.925	1.91	5.4	12.0	13.0	.75	.533	4.42
† A 502	29.5	17.660	.598	17.056	3.42						
† A 503	29.5	17.810	.604	17.104	3.96						
† A 504	30.0	14.828	.494	14.484	2.32						
† A 507	28.0	12.949	.463	11.584	10.50						
† B 501	30.0	13.976	.466	12.251	12.30	12.9	12.0	13.0	.75	.483	13.05
† B 502	30.5	14.755	.484	12.560	14.90						
† B 503	30.5	14.120	.463	12.187	13.70						
† B 505	29.5	14.440	.489	12.318	14.60						
† B 506	30.0	15.474	.516	13.965	9.75						
† C 501	30.0	14.205	.473	13.212	7.00	5.3	12.0	11.0	.75	.468	13.71
† C 502	30.0	14.350	.478	12.300	14.30						
† C 503	29.5	13.778	.467	12.406	9.97						
† C 504	29.5	13.670	.463	11.596	15.18						
† C 505	28.5	14.097	.494	12.180	13.60						
† C 506	28.5	13.534	.475	11.410	15.70						
† C 507	27.5	11.725	.426	9.354	20.20						
† D 501	30.	13.435	.448	12.914	3.88	16.7	12.	10.	.75	.458	4.12
† D 502	30.	13.560	.452	12.904	4.84						
† D 503	30.	13.709	.457	13.142	4.14						
† D 505	28.5	13.600	.477	13.105	3.64						
* E 501	30.	12.670	.422	12.272	3.14	1.4	10.	9.	1.5	.424	4.01
* E 502	30.	12.780	.426	12.239	4.24						
* E 503	30.	12.689	.423	12.256	3.42						
* E 504	30.	12.620	.421	12.051	4.51						
* E 505	30.	12.445	.415	11.972	3.80						
* E 506	30.	13.322	.444	12.676	4.85						

* Sap-wood.

† Partially sap-wood.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Shortleaf pine (*Pinus echinata*)											
*E 507	30.5	12.690	.416	12.166	4.13						
*F 501	30.	12.580	.419	8.494	32.5	2.1	9.	12.	2.	.424	25.36
*F 502	28.5	12.208	.428	10.080	17.45						
*F 504	31.0	13.259	.427	9.620	27.4						
*F 505	30.5	12.970	.425	9.558	26.35						
*F 506	30.5	12.920	.424	9.932	23.10						
*G 501	29.	12.243	.422	11.500	6.06	1.9	9.	9.	1.5	.422	6.68
*G 502	28.	11.897	.424	11.050	7.13						
*G 504	30.	12.775	.426	11.700	8.42						
*G 505	30.	12.668	.422	11.850	6.46						
*G 507	29.	11.993	.414	11.350	5.36						
*H 501	29.	12.283	.423	11.670	5.00	1.7	8.	8.	1.5	.426	8.29
*H 502	27.	11.424	.423	9.830	13.95						
*H 503	29.5	12.638	.428	11.062	12.48						
*H 504	30.	12.859	.428	12.475	2.99						
*H 505	29.5	12.634	.428	11.746	7.03						
*I 501	28.	12.440	.444	11.100	10.77	1.5	8.	19.	2.	.437	7.60
*I 502	27.5	12.040	.438	11.345	5.77						
*I 503	27.5	11.903	.433	11.146	6.36						
*I 504	28.5	12.320	.432	11.395	7.50						
*J 501	30.	12.895	.429	11.773	8.70	2.4	8.	16.	1.5	.414	7.22
*J 502	28.5	11.970	.420	11.092	7.33						
*J 503	28.	11.535	.412	10.770	6.64						
*J 504	28.	11.387	.407	10.680	6.22						
*K 501	30.	19.459	.648	18.400	5.45	1.7	8.	17.	1.5	.476	3.27
*K 502	30.	13.111	.437	12.550	4.27						
*K 503	29.5	12.110	.411	11.955	1.28						
*K 504	30.5	12.535	.411	12.274	2.08						
*L 501	30.	13.671	.456	10.610	22.4	1.5	8.	21.	2.0	.446	13.58
*L 502	28.5	12.445	.437	10.660	14.3						
*L 504	30.5	13.156	.431	11.720	10.9						
*L 505	30.5	13.465	.441	12.020	10.7						
*L 506	31.	14.414	.465	13.027	9.62						
*M 501	28.	12.207	.436	11.970	1.94	1.8	8.	13.	1.5	.459	2.07
*M 502	28.	12.305	.439	12.100	1.66						
*M 503	27.	13.569	.502	13.215	2.61						
*N 501	28.5	12.036	.422	11.500	4.46	1.5	9.	12.	1.5	.427	4.72
*N 502	28.	11.977	.428	11.521	3.82						
*N 503	27.	12.640	.468	11.850	6.25						
*N 504	28.25	11.705	.414	11.341	3.11						
*N 505	29.5	12.197	.413	11.436	6.25						
*N 506	29.5	12.455	.422	11.856	4.81						
*N 507	28.5	12.030	.422	11.387	5.34						
*O 502	31.	12.985	.418	9.645	25.7	1.4	10.	13.	2.	.426	25.35
*O 503	30.5	13.005	.426	11.235	13.6						
*O 504	31.5	13.373	.424	6.973	47.87						
*O 506	32.	13.716	.429	9.950	27.4						
*O 507	31.5	13.647	.433	11.975	12.20						
*P 501	28.5	24.610	.863	21.820	11.30	1.5	9.	9.	1.5	.450	28.80
*P 502	29.5	17.925	.607	14.270	20.40						
*P 503	29.	12.292	.424	8.900	27.60						
*P 504	30.	12.870	.429	8.520	33.80						
*P 505	30.	12.355	.412	7.510	39.20						
*P 506	30.	12.345	.411	9.300	24.70						
*P 507	30.3	12.747	.421	9.260	27.40						

* Sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
A 601	31.5	21.520	.683	19.639	8.74	1.9	28.3	11.	1.	.574	5.05
A 602	32.	18.651	.583	17.670	5.26						
A 603	32.	19.165	.599	17.979	6.19						
A 604	31.	16.328	.527	15.994	2.04						
A 605	30.5	16.082	.527	15.602	2.98						
A 606	31.5	16.648	.528	15.775	5.24						
A 607	31.5	18.552	.589	17.637	4.93						
A 608	30.25	16.805	.556	15.960	5.03						
B 601	30.	17.005	.567	16.477	3.11	4.1	28.3	8.5	1.0	.563	5.96
B 603	31.	18.695	.603	17.420	6.83						
B 605	30.5	16.455	.540	15.815	3.89						
B 606	30.	15.574	.519	15.272	1.94						
B 607	28.5	17.510	.614	16.603	5.18						
B 608	29.5	15.843	.537	13.502	14.80						
C 601	30.	16.650	.555	15.920	4.38	2.1	30.	7.0	2.0	.548	3.40
C 602	30.5	16.720	.548	16.319	2.4						
C 603	30.	16.500	.550	15.846	3.96						
C 604	30.	16.710	.557	16.230	2.87						
C 605	30.	16.065	.535	15.542	3.26						
C 606	29.5	15.758	.534	15.147	3.88						
C 607	29.5	16.393	.555	15.856	3.28						
C 608	28.5	15.645	.549	15.150	3.16						
D 601	28.5	16.110	.566	16.092	.11	8.4	30.	7.0	2.0	.545	1.28
D 605	28.5	15.243	.535	14.997	1.61						
D 606	29.	15.547	.536	15.220	2.11						
E 601	26.5	14.850	.561	14.841	.06	2.6	30.3	7.0	2.0	.554	3.18
E 602	28.5	15.973	.560	15.371	3.77						
E 603	27.5	15.918	.579	15.287	3.96						
E 604	28.5	15.632	.548	15.124	3.25						
E 605	28.5	15.067	.528	14.876	1.27						
E 606	27.5	14.784	.537	14.172	4.14						
E 607	28.	15.752	.562	14.990	4.83						
E 608	28.	15.487	.553	14.847	4.14						
F 601	28.	15.180	.542	14.830	2.31	4.9	31.	8.	2.5	.529	1.86
F 603	27.	14.370	.532	14.121	1.73						
F 605	27.	14.081	.521	13.845	1.68						
F 606	27.5	14.485	.526	14.400	.58						
F 607	28.5	14.935	.524	14.590	2.31						
F 608	27.25	14.430	.529	14.062	2.55						
G 601	31.	17.670	.570	17.328	1.94	5.2	31.	11.	3.	.581	3.07
G 602	31.	17.625	.568	17.003	3.52						
G 603	31.	17.380	.561	17.073	1.77						
G 604	29.	15.995	.552	15.742	1.58						
G 605	28.5	15.895	.557	15.666	1.44						
G 606	28.5	15.600	.547	15.255	2.21						
G 607	30.	18.760	.625	17.689	5.71						
G 608	29.5	19.845	.673	18.574	6.41						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Shortleaf pine (*Pinus echinata*)											
H 601	28.5	16.160	.567	15.982	1.10	2.5	31.	11.0	3.0	.564	1.62
H 602	29.	16.568	.571	16.420	.89						
H 603	30.	17.270	.573	17.054	1.25						
H 604	28.5	16.235	.570	16.023	1.3						
H 605	29.	16.234	.560	15.980	1.56						
H 606	28.	15.338	.548	15.033	1.98						
H 607	28.	15.751	.562	15.309	2.8						
H 608	27.5	15.332	.557	15.012	2.09						
I 601	29.	16.309	.562	15.956	2.16	3.7	32.	12.	3.25	.568	2.79
I 602	28.	15.890	.567	15.430	2.9						
I 603	29.5	16.840	.571	16.327	3.05						
I 604	28.	16.133	.576	15.615	3.21						
I 605	29.5	16.695	.566	16.176	3.11						
I 606	27.5	15.760	.573	15.233	3.34						
I 607	28.5	16.051	.563	15.525	3.28						
I 608	28.	15.829	.566	15.623	1.3						
A 701	30.	15.649	.522	15.601	.31	1.6	24.	13.	2.25	.531	.46
A 702	31.	16.689	.537	16.650	.23						
A 703	30.	15.896	.530	15.782	.72						
A 704	29.5	15.492	.525	15.412	.52						
A 705	28.	14.964	.535	14.856	.72						
A 706	28.5	15.126	.531	15.097	.19						
A 707	28.	14.990	.535	14.914	.51						
B 701	28.5	15.456	.542	15.100	2.3	1.6	25.	13.	3.0	.532	1.87
B 702	29.	15.790	.544	15.482	1.95						
B 703	28.	15.061	.538	14.779	1.87						
B 704	28.2	14.829	.526	14.619	1.42						
B 705	28.	14.640	.523	14.231	2.79						
B 706	29.	15.200	.524	14.982	1.44						
B 707	28.	14.715	.526	14.520	1.33						
C 701	28.5	15.840	.556	15.600	1.51	0.7	25.	13.	3.	.565	2.19
C 702	29.5	16.583	.562	16.150	2.62						
C 703	29.2	16.695	.571	16.260	2.61						
C 704	29.3	16.701	.570	16.320	2.28						
C 705	28.7	16.293	.567	15.980	1.94						
D 701	26.	14.880	.572	13.866	6.82	1.1	24.	16.	3.5	.556	2.47
D 702	27.5	15.147	.551	14.868	1.84						
D 703	28.	15.825	.565	15.577	1.57						
D 704	28.5	15.975	.560	15.755	1.38						
D 705	29.	15.972	.551	15.687	1.79						
D 706	30.	16.376	.546	16.067	1.89						
D 707	28.	15.333	.547	15.026	2.00						
E 701	30.	17.580	.586	16.853	4.13	0.6	24.	19.	3.75	.568	5.28
E 702	31.	18.483	.596	17.685	4.32						
E 703	30.	17.508	.583	17.386	.70						
E 704	29.75	16.762	.564	16.150	3.65						
E 705	29.	16.277	.561	15.434	5.18						
E 706	29.5	16.190	.548	14.328	11.50						
E 707	27.	14.563	.540	13.369	8.20						
F 701	31.	16.232	.524	15.047	7.30	1.2	24.	19.	4.	.531	5.34
F 702	30.	15.947	.532	14.910	6.50						
F 703	29.5	15.707	.532	13.806	12.10						
F 704	28.5	15.179	.532	14.780	2.63						
F 705	28.5	15.191	.533	14.765	2.81						
F 706	30.	15.925	.531	15.423	3.15						
F 707	29.5	15.761	.534	15.303	2.90						

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
G 701	28.5	15.985	.560	15.984	.01	2.2	24.	21.	4.5	.555	.35
G 702	27.5	15.724	.572	15.685	.25						
G 703	29.	16.335	.563	16.335	.00						
G 704	29.	15.975	.551	15.823	.95						
G 705	29.	15.775	.544	15.746	.18						
G 706	29.	15.861	.546	15.766	.60						
G 707	28.	15.465	.552	15.398	.43						
H 701	28.25	16.102	.570	15.821	1.75	.6	24.	21.	4.25	.559	1.97
H 702	27.	15.598	.577	15.311	1.84						
H 703	28.25	16.108	.570	15.791	1.97						
H 704	29.	16.650	.573	16.612	.23						
H 705	30.	16.286	.543	16.002	1.74						
H 706	30.	16.336	.544	16.107	1.40						
H 707	29.	15.690	.541	15.246	2.83						
I 701	31.	17.441	.562	17.028	2.37	1.4	24.	20.	5.	.544	4.26
I 702	28.2	15.891	.563	15.570	2.02						
I 703	29.9	16.337	.546	16.060	1.69						
I 704	29.1	15.530	.534	15.195	2.16						
I 705	29.8	15.301	.514	13.300	13.08						
A 801	28.	21.995	.785	20.460	6.99	1.9	80.	7.	1.5	.762	5.53
A 802	27.25	20.760	.762	20.072	3.32						
A 803	27.	20.248	.750	18.550	8.39						
A 804	27.	20.253	.750	19.400	4.21						
A 805	26.25	20.005	.762	19.060	4.73						
B 802	29.5	21.400	.725	20.742	3.07	3.4	70.	9.	2.	.730	2.79
B 803	28.25	20.764	.735	20.240	2.52						
C 801	29.	18.609	.642	17.672	5.03	4.6	35.	12.	2.5	.648	5.05
C 802	27.	17.000	.629	16.154	4.98						
C 803	27.5	17.950	.653	16.993	5.33						
C 804	28.	18.115	.647	17.286	4.58						
C 805	26.	16.900	.650	15.966	5.53						
C 806	26.5	17.380	.656	16.587	4.56						
C 807	26.	17.110	.658	16.199	5.32						
D 801	30.	20.272	.676	19.454	4.03	5.5	35.	12.	2.75	.668	4.35
D 802	28.	18.520	.661	17.657	4.66						
E 801	29.5	19.785	.670	19.049	3.72	5.5	32.	12.	2.75	.683	4.21
E 802	29.5	19.710	.668	18.851	4.36						
E 803	28.5	19.380	.680	18.528	3.88						
E 804	28.	19.390	.692	18.543	4.37						
E 805	28.	19.205	.685	18.301	4.66						
E 806	28.	19.363	.692	18.519	4.36						
E 807	28.	19.579	.699	18.776	4.10						
F 801	29.	19.318	.666	18.712	3.14	21.9	32.	14.	3.25	.717	5.66
F 802	28.	18.872	.674	18.000	4.62						
F 803	28.1	20.266	.721	19.332	4.61						
F 804	28.1	21.147	.752	19.500	7.79						
F 805	28.	21.766	.776	20.000	8.13						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Shortleaf pine (*Pinus echinata*)											
G 801	28.	18.020	.643	18.014	.03	11.7	40.	8.	4.	.727	3.70
G 802	27.5	18.285	.665	18.077	1.14						
G 803	27.	19.349	.716	18.572	4.02						
G 804	27.	20.155	.745	19.191	4.78						
G 805	27.	20.887	.774	19.842	5.00						
G 806	27.5	21.932	.797	20.603	6.06						
G 807	27.5	20.688	.752	19.688	4.84						
H 801	28.5	18.708	.656	18.460	1.33	2.90	38.	12.	3.75	.666	1.81
H 802	27.5	17.501	.636	17.171	1.89						
H 803	27.	17.914	.663	17.357	3.11						
H 804	27.	18.580	.688	18.008	3.08						
H 805	26.5	17.999	.679	17.627	2.08						
H 806	27.5	18.307	.666	18.211	.52						
H 807	27.5	18.647	.678	18.531	.62						
I 801	28.1	18.151	.646	17.072	5.94	5.6	37.	12.	3.5	.648	3.01
I 802	27.8	17.930	.645	17.620	1.73						
I 803	28.	18.371	.656	17.940	2.35						
I 804	28.	18.224	.651	17.735	2.68						
I 805	27.2	17.569	.646	17.160	2.33						
A 901	31.5	15.385	.488	15.085	1.95	10.1	23.	7.	1.25	.453	3.14
A 902	31.75	14.320	.451	14.164	1.09						
A 903	31.5	13.940	.443	13.545	2.83						
A 904	31.	13.648	.440	12.984	4.86						
A 905	30.5	13.498	.442	12.823	5.00						
B 901	29.4	14.850	.505	14.702	.99	1.74	23.	10.	2.25	.464	1.28
B 902	28.5	13.357	.468	13.210	1.10						
B 903	28.7	12.925	.450	12.735	1.47						
B 904	29.	12.917	.445	12.710	1.60						
B 905	28.8	12.980	.451	12.820	1.23						
C 901	31.	14.355	.462	14.012	2.39	7.22	23.	11.	2.25	.464	.80
C 902	31.25	14.575	.466	14.524	.35						
C 904	30.75	13.823	.450	13.820	.02						
C 907	31.	14.890	.480	14.822	.45						
D 901	29.	13.740	.474	13.710	.21	.78	22.	12.	2.75	.472	.22
D 902	28.	13.418	.479	13.380	.28						
D 903	28.	13.240	.473	13.214	.19						
D 904	28.5	13.435	.471	13.385	.37						
D 905	28.75	13.670	.475	13.619	.37						
D 906	30.5	14.325	.469	14.307	.12						
D 907	30.	14.000	.467	14.000	.00						
E 902	31.	15.575	.503	14.841	4.71	7.34	23.	12.	3.	.498	3.46
E 903	30.8	15.485	.503	14.689	5.14						
E 905	30.	14.981	.499	14.645	2.24						
E 906	31.	15.382	.496	14.993	2.53						
E 907	30.2	14.821	.491	14.418	2.72						
F 901	30.5	15.102	.495	15.081	.14	.4	23.	11.	3.25	.471	.25
F 902	29.7	14.243	.479	14.122	.85						
F 903	28.5	13.270	.466	13.192	.59						
F 904	28.7	13.310	.464	13.308	.01						
F 905	28.7	13.365	.466	13.352	.09						
F 906	29.5	13.575	.460	13.569	.04						
F 907	28.5	13.400	.470	13.392	.06						
G 901	30.	14.452	.482	14.345	.74	1.94	24.	10.	3.5	.481	1.89
G 902	28.9	13.823	.478	13.538	2.06						
G 903	28.	13.500	.482	13.220	2.08						
G 904	28.6	13.843	.484	13.560	2.04						

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
G 905	29.1	13.954	.479	13.681	1.96						
G 906	29.	13.947	.481	13.651	2.12						
G 907	28.9	13.907	.481	13.596	2.24						
H 901	29.2	14.335	.491	14.070	1.85	1.14	24.	10.	3.5	.487	2.21
H 902	28.7	14.115	.492	13.892	1.58						
H 903	28.	13.685	.488	13.390	2.16						
H 904	29.	14.180	.489	13.761	2.95						
H 905	29.7	14.365	.484	14.111	1.77						
H 906	30.	14.525	.484	14.062	3.19						
H 907	30.5	14.660	.481	14.365	2.01						
I 901	30.4	15.004	.494	14.865	.93	.54	24.	12.	4.25	.487	1.17
I 902	29.3	14.380	.491	14.228	1.06						
I 903	28.2	13.827	.491	13.667	1.16						
I 904	29.6	14.365	.485	14.165	1.39						
I 905	30.	14.592	.486	14.447	1.20						
I 906	30.	14.501	.483	14.333	1.16						
I 907	30.5	14.720	.483	14.526	1.32						
A1001	30.	19.410	.647	18.491	4.74	27.76	20.	17.	1.75	.787	8.58
A1002	30.	20.885	.696	19.711	5.62						
A1003	30.	20.100	.670	18.813	5.91						
A1004	30.	21.670	.722	20.020	7.61						
A1005	29.	26.123	.900	23.175	11.30						
A1006	28.5	28.968	1.016	25.303	12.68						
A1007	28.	24.110	.861	21.176	12.2						
B1001	30.	16.440	.548	16.121	1.94	17.56	20.	14.	1.5	.688	2.51
B1002	30.5	17.456	.572	17.092	2.08						
B1003	30.	17.380	.579	17.320	.35						
B1004	30.	18.717	.624	18.680	.20						
B1005	30.	22.670	.756	22.104	2.49						
B1006	29.5	27.575	.935	26.022	5.63						
B1007	28.2	22.661	.804	21.551	4.90						
C1001	31.	18.490	.596	17.987	2.72	6.12	20.	21.	2.	.599	2.44
C1002	30.5	19.945	.654	19.111	4.18						
C1003	30.	18.040	.601	17.502	2.98						
C1004	30.	17.640	.588	17.419	1.25						
C1005	30.	17.680	.589	17.359	1.82						
C1006	30.	18.025	.601	17.726	1.66						
C1007	29.7	16.730	.563	16.317	2.47						
D1001	28.	14.798	.528	14.757	.28	17.3	21.	22.	2.75	.581	1.41
D1002	28.2	15.240	.540	15.172	.45						
D1003	28.	15.245	.544	15.129	.76						
D1004	28.	15.427	.551	15.313	.74						
D1005	28.	17.479	.624	17.096	2.19						
D1006	28.	17.768	.634	17.467	1.69						
D1007	28.5	18.459	.648	17.768	3.74						
E1001	28.	15.128	.541	14.905	1.47	3.7	24.	23.	2.5	.582	1.77
E1002	28.	15.801	.564	15.630	1.08						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Shortleaf pine (*Pinus echinata*)											
E1003	27.9	15.705	.563	15.546	1.01						
E1004	28.	16.252	.580	15.980	1.67						
E1005	28.7	17.078	.594	16.839	1.40						
E1006	29.	18.225	.628	17.732	2.71						
E1007	28.1	17.109	.609	16.579	3.10						
F1001	29.	16.505	.569	16.496	.05	2.56	24.	23.	2.75	.576	.04
F1002	29.1	16.883	.580	16.883	0.00						
F1003	28.1	16.530	.588	16.520	.06						
F1004	28.5	16.482	.578	16.475	.04						
G1001	29.6	17.092	.576	16.871	1.29	2.2	24.	17.	3.5	.584	1.27
G1002	29.	16.813	.580	16.698	.68						
G1003	28.	16.480	.588	16.265	1.31						
G1004	28.2	16.621	.589	16.338	1.70						
G1005	28.7	16.770	.584	16.611	.95						
G1006	28.4	16.659	.590	16.326	2.00						
G1007	29.	16.856	.581	16.693	.97						
H1001	29.	17.563	.605	17.560	.02	2.14	24.	17.	3.5	.604	.36
H1002	28.5	17.513	.615	17.482	.18						
H1003	28.	16.965	.606	16.792	1.02						
H1004	28.	16.914	.604	16.847	.40						
H1005	28.4	17.251	.607	17.223	.16						
H1006	28.3	17.203	.607	17.185	.10						
H1007	28.2	16.540	.586	16.431	.66						
I 1001	30.3	18.510	.611	18.500	.05	.9	25.	15.	3.75	.607	.68
I 1002	29.8	17.778	.596	17.750	.16						
I 1003	28.2	17.085	.606	16.980	.62						
I 1004	28.3	17.460	.617	17.231	1.31						
I 1007	30.	18.220	.607	17.978	1.33						
A1101	27.5	18.428	.670	17.263	6.31	22.98	16.	14.	.5	.674	5.90
A1102	27.7	18.597	.671	17.392	6.49						
A1103	28.	18.594	.663	17.427	6.27						
A1104	28.7	18.881	.657	17.742	6.03						
A1105	28.	19.837	.708	18.964	4.4						
A1106	28.2	26.795	.950	24.380	9.02						
B1101	28.2	19.295	.684	18.378	4.75	20.32	16.	12.	.5	.666	3.92
B1102	28.	18.223	.652	17.580	3.53						
B1103	27.9	18.525	.664	17.818	3.82						
B1104	29.	19.242	.664	18.560	3.54						
C1101	30.	17.865	.595	17.260	3.39	18.5	16.	13.	.5	.646	3.84
C1102	30.1	17.890	.594	17.740	.84						
C1103	29.9	19.519	.653	18.551	4.96						
C1104	30.5	22.693	.744	21.290	6.18						
D1101	29.5	20.353	.690	18.599	8.62	21.04	16.	17.	.5	.682	8.68
D1102	28.7	19.956	.696	18.279	8.40						
D1103	28.5	19.127	.672	17.789	7.00						
D1104	29.2	19.940	.683	18.131	9.03						
D1105	28.3	19.110	.676	17.383	9.03						
D1106	28.7	19.445	.677	17.498	10.01						
†E1102	28.5	16.715	.587	15.494	7.30	‡14.32	10.	32.	1.5	.526	5.36
†E1103	29.2	15.424	.528	14.250	7.60	* 3.68					
†E1104	30.	14.660	.488	14.398	1.79						
†E1105	30.	15.078	.502	14.360	4.76						

* Sap-wood.

† Partially sap-wood.

‡ Percentage of resin in heart-wood where both heart-wood and sap-wood occur in the same culture block.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Shortleaf pine (*Pinus echinata*)											
†F1101	28.	13.630	.487	13.106	3.84	‡10.64	11.	35.	1.5	.495	3.34
†F1102	28.4	13.823	.487	13.358	3.36	* 2.5					
†F1103	28.8	13.965	.485	13.380	4.19						
†F1104	29.5	14.045	.476	13.750	2.10						
†F1105	29.	13.836	.477	13.568	1.93						
†F1106	30.	16.875	.562	16.083	4.70						
†G1101	28.5	16.462	.577	14.637	11.10	‡ 8.94	13.	32.	1.5	.539	6.75
†G1102	29.3	15.597	.532	14.593	6.45	* 2.68					
†G1103	29.2	15.276	.523	14.545	4.78						
†G1104	29.	14.577	.503	13.897	4.66						
†H1101	28.	16.190	.578	15.450	4.57	‡25.34	13.	31.	1.5	.551	5.25
†H1102	28.7	16.340	.570	15.260	6.61	* 6.58					
†H1103	28.3	15.070	.532	14.260	5.38						
†H1104	28.2	14.775	.524	14.120	4.44						
†I 1101	28.	13.066	.467	11.665	10.7	‡18.3	12.	31.	1.5	.469	11.6
†I 1102	27.2	12.858	.472	11.470	10.8	* 4.68					
†I 1103	27.8	12.595	.453	11.140	11.5						
†I 1104	28.3	13.690	.483	11.870	13.3						
†J 1101	30.	13.410	.447	11.322	15.5	‡13.38	13.	33.	1.5	.487	12.4
†J 1102	29.5	12.893	.437	10.834	15.9	* 1.88					
†J 1103	29.5	15.535	.527	14.030	9.68						
†J 1104	28.	15.080	.538	13.790	8.55						
†K1101	29.	12.999	.447	9.505	26.9	‡ 2.04	11.	30.	2.	.428	31.8
†K1102	29.	12.466	.430	9.192	26.2	* 1.78					
†K1103	29.25	12.266	.419	7.095	42.1						
†K1104	29.	12.127	.418	8.220	32.2						
†L1101	28.8	12.595	.437	8.990	28.6	1.36	7.	23.	2.	.433	54.3
†L1102	29.5	12.646	.428	5.160	59.2						
†L1103	29.	12.565	.433	4.801	61.8						
†L1104	28.7	12.497	.435	5.271	67.8						
*M110	28.	11.920	.426	3.282	72.4	1.44	6.	15.	2.75	.426	57.1
*M1102	27.5	11.675	.425	5.294	54.6						
*M1103	27.3	11.525	.423	5.763	50.0						
*M1104	28.	12.040	.430	5.808	51.7						
*N1101	28.	12.184	.435	7.996	34.4	1.26	6.	18.	2.5	.433	30.51
*N1102	27.7	12.012	.434	7.870	34.45						
*N1103	28.	11.963	.427	8.220	31.3						
*N1104	28.2	12.306	.436	9.610	21.9						
*O1101	27.7	12.481	.450	8.734	30.	3.56	6.	18.	2.5	.453	21.1
*O1102	27.2	12.334	.454	9.483	23.1						
*O1103	26.7	12.076	.452	10.414	13.7						
*O1104	27.	12.332	.457	10.565	14.3						
*O1105	27.5	12.432	.452	9.045	27.2						

* Sap-wood.

† Partially sap-wood.

‡ Percentage of resin in heart-wood where both heart-wood and sap-wood occur in the same culture block.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Shortleaf pine (*Pinus echinata*)											
*O1106	27.7	12.563	.453	10.219	18.7						
*P1101	27.	12.650	.468	6.330	50.	3.24	6.	13.	2.75	.461	52.5
*P1102	27.5	12.628	.459	5.112	59.5						
*P1103	26.7	12.188	.456	5.146	57.8						
*P1104	27.	12.229	.453	4.885	60.0						
*P1105	27.	12.122	.448	6.163	49.0						
*P1106	29.4	14.151	.482	8.506	39.9						
Longleaf pine (*Pinus palustris*)											
A1201	30.3	19.512	.644	18.795	3.67	.82	30.	22.	0.75	.656	3.12
A1202	30.	19.246	.641	18.579	3.46						
A1203	30.	19.475	.649	18.818	3.38						
A1204	30.2	19.851	.657	19.267	2.94						
A1205	30.	19.994	.666	19.371	3.12						
A1206	29.3	19.562	.667	18.962	3.07						
A1207	28.5	19.106	.670	18.690	2.18						
B1201	32.	20.360	.636	19.887	2.32	.94	35.	17.	.75	.627	1.81
B1203	31.1	19.681	.633	19.368	1.59						
B1204	31.5	19.838	.630	19.472	1.84						
B1205	31.	19.377	.625	19.050	1.69						
B1207	30.4	18.625	.612	18.322	1.62						
C1201	30.1	21.117	.701	20.870	1.17	1.42	35.	18.	1.5	.699	1.72
C1202	30.	20.967	.698	20.484	2.31						
C1203	30.7	21.647	.706	21.301	1.60						
C1204	30.6	21.632	.707	21.235	1.84						
C1205	30.5	21.433	.702	21.056	1.76						
C1206	30.	20.739	.691	20.509	1.11						
C1207	30.	20.795	.693	20.331	2.23						
D1201	31.	20.124	.648	20.068	.28	1.64	35.	17.	1.5	.655	1.31
D1202	31.3	20.599	.658	20.365	1.13						
D1203	32.	21.307	.666	21.070	1.11						
D1204	32.	20.910	.654	20.410	2.39						
D1205	31.2	20.352	.652	20.020	1.63						
E1201	32.	20.308	.635	20.300	.04	27.84	30.	16.	2.5	.641	8.13
E1202	31.2	19.628	.629	17.310	11.80						
E1203	31.9	20.115	.630	18.240	9.34						
E1204	32.	20.302	.635	18.370	9.52						
E1205	32.3	20.867	.646	18.850	9.64						
E1206	32.1	21.062	.656	19.570	7.09						
E1207	32.6	21.289	.654	19.270	9.48						
F1201	28.	22.718	.811	22.455	1.16	13.54	30.	17.	2.5	.840	6.90
F1202	28.	23.225	.830	21.649	6.78						
F1203	28.8	24.391	.847	22.348	8.39						
F1204	29.3	24.814	.847	22.970	7.43						
F1205	29.4	25.189	.856	22.985	8.74						
F1206	28.9	24.627	.852	22.342	9.28						
F1207	28.	23.536	.840	21.990	6.56						
G1201	31.5	30.702	.974	27.666	9.89	22.14	30.	18.	3.5	.956	10.11
G1202	30.	28.835	.961	25.636	11.10						
G1203	29.9	28.450	.951	25.371	10.80						
G1204	28.7	27.499	.958	24.820	9.74						
G1205	28.6	26.801	.937	24.376	9.05						
H1201	33.7	21.353	.633	21.210	.67	1.48	28.	16.	3.5	.633	.64
H1202	31.	19.308	.623	19.198	.57						
H1204	31.9	20.200	.633	20.090	.55						

* Sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
H1206	32.	20.473	.640	20.320	.75						
H1207	32.	20.353	.635	20.222	.64						
I 1201	31.4	31.454	1.000	29.222	7.09	25.26	30.	18.	4.5	1.025	6.63
I 1202	28.3	28.911	1.022	26.600	8.00						
I 1203	30.	30.981	1.030	29.040	6.26						
I 1204	31.	33.061	1.066	31.040	6.11						
I 1207	30.5	30.687	1.006	28.930	5.72						
A1301	31.9	24.630	.772	24.000	2.55	7.04	37.	27.	2.0	.787	1.41
A1302	30.9	24.150	.781	23.900	1.03						
A1303	31.1	24.691	.794	24.410	1.14						
A1304	32.	25.301	.790	24.960	1.35						
A1305	32.	25.504	.797	25.250	1.00						
B1301	31.5	23.882	.758	23.350	2.22	7.42	37.	27.	2.0	.807	3.93
B1302	32.	24.265	.758	23.625	2.64						
B1303	32.7	25.231	.771	24.506	2.87						
B1304	33.1	25.871	.781	25.148	2.79						
B1305	32.	25.921	.809	24.936	3.8						
B1306	32.6	29.638	.909	27.681	6.6						
B1307	31.8	27.549	.866	25.727	6.61						
C1301	32.	23.599	.737	23.310	1.22	2.52	37.	28.	2.5	.728	1.03
C1302	32.1	23.704	.738	23.420	1.20						
C1303	32.3	23.706	.734	23.437	1.13						
C1304	32.	23.596	.737	23.290	1.30						
C1305	31.7	22.825	.720	22.500	1.42						
C1306	32.	23.040	.720	23.056	?0.00						
C1307	31.5	22.392	.711	22.190	.9						
D1301	31.2	23.948	.767	23.301	2.71	2.58	37.	29.	2.5	.760	2.35
D1302	31.3	23.971	.766	23.298	2.81						
D1303	32.	24.448	.764	23.942	2.07						
D1304	31.9	24.151	.757	23.700	1.87						
D1305	32.	23.944	.748	23.398	2.28						
E1301	32.	28.279	.883	26.517	6.23	25.88	39.	30.	3.0	.951	8.45
E1302	32.5	29.872	.919	27.500	7.94						
E1303	33.3	31.460	.944	28.670	8.87						
E1304	32.2	31.152	.967	28.140	9.66						
E1305	32.1	31.644	.985	28.720	9.24						
E1306	33.	32.300	.979	29.500	8.67						
E1307	31.2	30.420	.978	27.810	8.58						
F1301	33.2	22.656	.682	22.230	1.88	4.48	39.	28.	3.0	.667	2.17
F1302	32.2	21.820	.677	21.433	1.77						
F1303	32.	21.269	.663	20.806	2.18						
F1304	32.	21.471	.672	20.974	2.31						
F1305	33.	21.666	.657	21.143	2.41						
F1306	32.9	21.557	.655	21.040	2.40						
F1307	32.2	21.326	.663	20.840	2.28						
G1301	31.	20.421	.659	19.850	2.79	‡6.60	39.	32.	4.	.653	3.48

‡ Percentage of resin in heart-wood where both heart-wood and sap-wood occur in the same culture block.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
G1302	31.2	20.569	.658	19.819	3.65	*3.24					
G1303	30.7	20.128	.655	19.315	4.04						
G1304	30.6	20.071	.656	19.339	3.64						
G1305	30.9	20.245	.655	19.519	3.58						
G1306	30.8	20.148	.654	19.492	3.26						
G1307	30.	19.184	.639	18.536	3.38						
*H1301	31.7	18.709	.590	16.479	11.92	2.36	31.	14.	5.	.592	10.04
*H1304	31.8	18.499	.581	16.500	10.80						
*H1305	32.	18.994	.593	17.200	9.44						
*H1306	32.	19.223	.600	17.549	8.71						
*H1307	30.9	18.433	.596	16.710	9.35						
A1401	32.1	17.873	.557	17.360	2.87	3.94	20.	7.5	3.25	.582	3.94
A1402	31.2	17.755	.569	17.120	3.58						
A1403	32.	20.249	.633	19.105	5.65						
A1405	31.8	18.187	.572	17.520	3.67						
B1401	32.	17.513	.547	16.885	3.59	4.88	20.	6.5	3.25	.616	3.66
B1402	31.9	17.943	.563	17.440	2.81						
B1403	32.	23.658	.738	22.572	4.59						
C1401	31.	18.728	.604	18.093	3.39	5.9	20.	7.	3.5	.610	4.69
C1402	32.	19.926	.622	18.780	5.75						
C1403	32.1	19.499	.607	18.653	4.34						
C1404	32.	19.394	.606	18.370	5.28						
D1401	31.9	20.143	.631	19.245	4.47	4.3	22.	8.	3.5	.601	3.63
D1402	32.5	19.496	.600	18.728	3.94						
D1403	32.	18.759	.587	18.260	2.66						
D1404	32.	18.747	.586	18.100	3.45						
E1403	32.	17.613	.550	17.002	3.47	5.22	22.	9.	4.25	.548	3.68
E1404	32.2	17.728	.551	16.997	4.12						
E1405	33.	17.999	.545	17.380	3.44						
F1401	32.	18.885	.590	18.721	.87	5.62	22.	9.	4.25	.596	.91
F1402	32.1	20.137	.627	19.897	1.19						
F1403	32.	19.254	.601	19.132	.63						
F1404	32.1	18.887	.588	18.881	.03						
F1405	31.5	18.412	.584	18.127	1.55						
F1406	31.8	18.596	.585	18.372	1.21						
G1401	31.8	18.403	.578	17.926	2.59	8.66	22.	10.	5.	.576	3.03
G1404	32.	17.953	.561	17.380	3.19						
G1405	31.8	18.245	.574	17.627	3.39						
G1406	32.6	19.334	.593	18.750	3.02						
†H1401	33.1	19.199	.580	17.521	8.74	‡ 5.18	28.	8.	5.	.570	11.77
†H1403	32.9	18.782	.571	16.222	13.63	* 2.32					
†H1404	32.6	18.282	.560	15.914	12.95						
†I 1401	33.5	18.781	.561	14.310	23.8	‡ 8.68	20.	10.5	5.5	.559	18.07
†I 1403	33.8	18.196	.538	14.120	22.4	* 1.98					
†I 1405	31.	17.950	.578	15.981	10.97						
†I 1406	32.7	18.313	.560	15.550	15.10						
A1501	32.7	21.383	.653	21.066	1.48	.76	28.	11.	1.25	.654	1.44
A1502	31.	20.097	.648	19.805	1.45						
A1503	31.4	20.766	.661	20.478	1.39						
B1501	32.	21.361	.667	21.272	.42	.84	28.	9.	1.25	.680	.32
B1502	32.8	21.807	.665	21.740	.31						
B1503	33.5	22.638	.675	22.567	.31						

* Sap-wood.

† Partially sap-wood.

‡ Percentage of resin in heart-wood where both heart-wood and sap-wood occur in the same culture block.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
B1504	31.9	22.070	.691	21.982	.40						
B1505	32.7	22.618	.692	22.567	.23						
B1506	31.3	21.668	.693	21.613	.25						
C1501	32.	23.877	.715	23.865	.05	.96	30.	11.	2.25	.717	.49
C1502	31.4	23.618	.720	23.470	.63						
C1503	31.1	23.491	.724	23.381	.47						
C1504	31.	23.310	.719	23.070	1.03						
C1505	31.8	23.774	.714	23.697	.32						
C1506	30.4	22.550	.709	22.452	.44						
D1501	34.	23.984	.705	23.875	.46	.88	30.	14.	2.25	.698	.37
D1502	35.	24.217	.692	24.129	.36						
D1503	34.	23.707	.697	23.612	.40						
D1504	34.	23.678	.697	23.609	.29						
D1505	34.9	24.447	.700	24.378	.28						
D1506	33.	23.011	.697	22.914	.42						
E1501	33.5	24.192	.722	23.490	2.91	.86	35.	17.	3.25	.724	2.68
E1502	33.	24.027	.727	23.406	2.58						
E1503	33.3	24.095	.724	23.480	2.55						
†F1501	34.2	24.660	.721	23.862	3.23	1.06	30.	15.	4.	.709	3.35
†F1502	34.9	25.570	.733	24.737	3.26						
†F1503	34.8	25.163	.723	24.166	3.96						
†F1504	34.1	24.227	.710	23.512	2.95						
†F1505	34.	23.332	.685	22.672	2.83						
†F1506	32.8	22.518	.685	21.640	3.90						
*G1501	33.8	22.846	.676	22.200	2.82	.96	32.	11.	5.	.685	3.30
*G1502	33.7	23.110	.685	22.498	2.65						
*G1503	32.7	22.492	.687	22.113	1.69						
*G1504	32.3	22.362	.691	20.991	6.13						
*G1505	31.2	21.520	.689	20.825	3.23						
*G1506	31.5	21.725	.689	21.006	3.31						
A1601	32.	24.225	.757	22.970	5.18	2.7	40.	23.	1.25	.746	4.38
A1602	32.2	24.478	.761	23.540	3.83						
A1603	32.	23.927	.747	22.480	6.04						
A1604	32.	23.431	.732	22.850	2.48						
B1601	30.8	22.798	.740	20.480	10.18	2.44	40.	20.	1.75	.726	8.57
B1602	31.	22.404	.722	20.490	8.54						
B1603	30.7	22.002	.716	20.450	7.05						
C1601	30.	22.000	.733	19.710	10.41	5.44	38.	17.	2.75	.740	10.11
C1602	30.7	22.717	.740	20.600	9.31						
C1604	30.6	22.869	.747	20.440	10.61						
D1601	30.2	23.052	.763	22.250	3.48	3.4	40.	17.	3.75	.768	3.10
D1602	30.3	23.431	.773	22.795	2.71						
†E1601	32.	22.439	.701	22.057	1.70	2.04	35.	16.	4.75	.696	8.68
†E1602	30.	20.692	.690	17.480	15.5						
†E1603	30.5	21.245	.696	21.239	.03						

* Sap-wood.

† Partially sap-wood.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
†E1604	30.	20.971	.699	17.310	17.5						
*F1601	30.9	20.386	.658	19.570	4.01	3.20	40.	10.	5.75	.664	8.19
*F1602	29.5	19.445	.658	16.990	12.62						
*F1603	29.7	19.949	.671	19.270	3.41						
*F1604	30.	20.055	.668	17.500	12.75						
*G1601	31.2	21.288	.682	17.740	16.65	2.58	37.	12.	6.75	.681	12.56
*G1602	31.	20.970	.676	17.605	16.05						
*G1603	30.4	20.720	.681	20.691	.14						
*G1604	29.5	20.280	.687	16.741	17.4						
*H1601	32.5	21.834	.671	20.275	7.14	2.14	39.	8.5	7.75	.670	6.74
*H1602	31.8	21.292	.670	19.940	6.34						
*I 1601	30.9	22.364	.723	18.460	17.45	1.84	36.	10.	8.75	.721	17.09
*I 1602	31.	22.165	.715	17.855	19.45						
*I 1603	30.2	21.879	.724	18.270	16.45						
*I 1604	29.7	21.480	.724	18.250	15.01						
A1701	32.	23.846	.745	22.719	4.72	32.48	25.	10.	.5	.733	5.87
A1702	31.6	22.075	.699	21.156	4.16						
A1703	30.	21.282	.709	20.061	5.73						
A1704	28.	20.557	.734	19.272	6.25						
A1705	26.	20.252	.778	18.532	8.49						
B1701	31.	22.809	.735	20.738	9.08	23.8	25.	10.	.5	.717	8.06
B1702	30.7	21.684	.706	20.142	7.11						
B1703	32.3	22.067	.683	20.568	6.79						
B1704	31.	22.257	.717	20.710	6.95						
B1705	32.	23.851	.745	21.370	10.40						
C1703	30.2	18.847	.624	18.360	2.58	13.94	25.	8.	1.5	.629	2.68
C1704	28.3	17.566	.620	17.100	2.65						
C1705	28.9	18.337	.634	17.820	2.82						
D1701	32.	20.694	.646	19.440	6.06	15.0	25.	9.	1.5	.643	8.33
D1702	31.5	19.996	.634	18.992	5.02						
D1703	32.5	20.891	.643	19.370	7.28						
D1704	30.8	19.481	.633	16.449	15.56						
D1705	31.7	20.963	.661	19.342	7.74						
E1701	31.6	22.239	.703	21.206	4.64	10.46	28.	14.	2.5	.683	4.56
E1702	32.3	22.076	.684	21.050	4.65						
E1703	31.5	21.488	.683	20.691	3.71						
E1704	31.9	21.510	.674	20.379	5.26						
E1705	31.9	21.518	.674	20.540	4.55						
F1701	32.	19.850	.620	19.128	3.64	10.6	29.	12.	2.5	.629	3.41
F1702	32.1	19.908	.620	19.110	4.01						
F1703	31.7	19.440	.613	19.438	.01						
F1704	32.3	20.683	.640	19.776	4.39						
F1705	32.	20.971	.655	19.923	5.00						
G1701	31.8	20.292	.638	19.573	3.54	4.7	28.	13.	3.5	.617	3.23
G1702	31.6	19.995	.632	19.225	3.85						
G1703	31.	19.117	.616	18.528	3.08						
G1704	30.8	18.587	.603	18.010	3.11						
G1705	30.	17.905	.597	17.443	2.58						
H1701	32.3	24.521	.759	22.716	7.36	13.2	30.	18.	3.5	.726	7.00
H1702	32.	23.870	.746	21.913	8.19						
H1703	32.	23.138	.722	21.451	7.29						
H1704	32.7	22.986	.703	21.561	6.2						
H1705	31.2	21.923	.703	20.611	5.99						
A1801	31.	19.791	.638	19.100	3.49	2.7	20.	12.	.75	.599	2.15

* Sap-wood.
† Partially sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
A1802	31.8	19.095	.600	18.520	3.01						
A1803	32.	19.476	.608	18.910	2.9						
A1804	30.9	18.943	.613	18.650	1.55						
A1805	31.2	17.795	.570	17.686	.61						
A1806	31.	17.523	.565	17.291	1.32						
B1801	30.	18.092	.603	18.070	.12	5.9	20.	13.	.75	.621	1.21
B1802	28.7	17.594	.613	17.591	.02						
B1803	29.	19.345	.667	19.004	1.76						
B1804	28.9	18.547	.642	18.243	1.64						
B1805	29.6	17.809	.601	17.504	1.71						
B1806	30.5	18.312	.600	18.132	.98						
C1801	30.8	24.037	.780	23.004	4.30	3.9	25.	19.	1.5	.582	1.01
C1802	30.8	17.134	.556	17.015	.69						
C1803	31.4	17.172	.547	17.022	.87						
C1804	31.1	16.913	.543	16.913	.00						
C1805	31.2	16.742	.537	16.733	.05						
C1806	31.8	16.800	.528	16.782	.11						
D1801	31.	18.253	.588	18.010	1.33	3.96	25.	14.	1.5	.568	1.68
D1802	32.5	19.230	.591	18.757	2.46						
D1803	32.6	18.507	.567	18.126	2.06						
D1804	30.2	16.554	.548	16.451	.62						
D1805	29.	16.153	.557	15.978	1.08						
D1806	29.	16.200	.558	15.786	2.56						
E1801	30.6	16.229	.530	16.040	1.17	5.4	27.	18.	2.5	.527	.91
E1802	30.5	15.997	.524	15.940	.36						
E1803	30.1	15.783	.524	15.670	.72						
E1804	31.1	16.441	.529	16.212	1.39						
F1802	32.7	18.750	.574	18.010	3.95	3.	27.	26.	2.5	.536	2.26
F1803	31.	16.393	.528	16.215	1.09						
F1804	31.9	16.762	.525	16.500	1.57						
F1805	31.5	16.520	.524	16.170	2.12						
F1806	32.	16.994	.530	16.550	2.61						
**G1801	31.	31.403	1.013	28.107	10.49	5.56	27.	26.	3.5	.576	2.15
G1802	31.8	16.189	.508	16.102	.54						
G1803	30.7	14.460	.471	14.221	1.65						
G1804	31.5	15.226	.483	15.212	.09						
G1805	32.	15.542	.486	15.540	.01						
G1806	32.4	16.067	.496	16.052	.09						
H1801	32.4	16.985	.524	16.465	3.06	4.12	27.	23.	3.5	.523	3.38
H1802	34.7	18.515	.533	17.996	2.8						
H1803	32.	16.915	.528	16.271	3.81						
H1804	33.3	17.283	.519	16.711	3.31						
H1805	32.	16.625	.519	16.006	3.72						
H1806	32.2	16.726	.519	16.123	3.6						
I 1802	35.1	20.556	.585	20.214	1.67	4.14	28.	36.	4.5	.531	.90
I 1803	31.9	16.523	.517	16.491	.19						
I 1804	32.	16.713	.522	16.642	.43						

** Knot.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
I 1805	31.	16.052	.518	15.890	1.01						
I 1806	31.8	16.368	.515	16.173	1.19						
A1901	32.5	20.185	.620	19.286	4.46	2.7	30.	17.	.5	.636	3.10
A1902	31.4	19.275	.614	18.711	2.93						
A1903	32.	20.354	.636	19.791	2.77						
A1904	32.1	21.326	.663	20.735	2.78						
A1905	30.	19.441	.648	18.944	2.56						
B1901	30.	20.005	.667	18.432	7.87	3.16	32.	12.	.5	.668	4.29
B1902	31.5	20.733	.657	20.035	3.37						
B1903	31.	22.092	.712	21.506	2.65						
B1904	30.8	20.277	.658	19.805	2.32						
B1905	30.5	19.736	.647	18.694	5.28						
C1901	32.5	22.598	.695	21.780	3.62	3.22	40.	12.	1.5	.701	3.24
C1902	31.5	21.881	.695	21.000	4.03						
C1903	30.7	22.732	.740	21.950	3.44						
C1904	30.	20.654	.688	20.130	2.53						
C1905	30.3	20.784	.686	20.250	2.57						
D1901	32.7	22.412	.685	21.861	2.46	4.24	40.	10.	2.5	.684	2.33
D1902	31.9	22.249	.697	21.754	2.32						
D1903	32.5	22.814	.702	22.272	2.37						
D1904	32.	21.634	.675	21.135	2.30						
D1905	31.5	20.913	.664	20.449	2.22						
E1901	31.	21.130	.681	20.770	1.70	8.86	42.	9.	3.5	.705	2.08
E1903	31.2	22.398	.717	21.948	2.01						
E1904	31.5	22.637	.718	22.063	2.54						
F1901	33.3	23.500	.706	21.433	8.80	6.3	35.	12.	4.5	.713	8.83
F1902	32.7	23.200	.709	21.091	9.09						
F1903	32.	22.977	.718	20.825	9.38						
F1904	32.	22.884	.715	20.890	8.71						
F1905	31.	22.318	.720	20.496	8.16						
G1901	31.5	21.116	.670	21.054	.29	16.26	37.	13.	5.5	.684	1.86
G1902	33.7	22.769	.675	22.540	1.01						
G1903	32.9	22.054	.670	22.037	.08						
G1904	33.4	23.037	.689	22.319	3.11						
G1905	32.	22.936	.716	21.831	4.82						
H1901	33.8	22.130	.654	21.384	3.37	25.68	36.	12.	6.5	.742	9.06
H1904	34.8	26.802	.770	24.063	10.21						
H1905	34.	27.271	.803	23.565	13.59						
Loblolly pine (*Pinus Taeda*)											
B2001	31.	15.685	.506	14.522	7.42	30.6	14.	2.0	2.25	.500	15.44
B2002	29.5	14.438	.490	13.515	6.39						
B2003	29.8	14.630	.491	13.535	7.48						
B2004	31.	15.601	.503	11.450	26.6						
B2005	31.2	15.879	.508	11.226	29.3						
C2001	30.	15.778	.526	15.406	2.36	6.0	13.	1.5	3.	.519	1.47
C2002	28.	15.140	.541	14.927	1.41						
C2003	28.7	14.847	.517	14.820	.18						
C2004	29.5	14.980	.507	14.852	.86						
C2005	28.	14.156	.505	13.794	2.56						
D2001	30.	15.720	.527	15.117	3.84	4.96	17.	2.	2.75	.518	4.00
D2002	29.7	15.404	.518	14.820	3.79						
D2004	32.	16.183	.505	15.475	4.38						
E2001	31.3	18.350	.586	12.258	33.20	2.9	14.	1.5	2.25	.504	23.17
E2002	31.	16.669	.538	13.263	20.42						
E2003	31.	14.575	.470	11.630	20.22						

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Loblolly pine (*Pinus Taeda*)											
E2004	30.7	14.376	.468	10.932	23.99						
E2005	28.	12.830	.458	10.521	18.00						
F2001	31.4	15.120	.481	12.201	19.30	6.08	12.	1.5	2.75	.472	21.67
F2004	31.3	14.655	.468	10.883	25.72						
F2005	29.	13.520	.466	9.818	19.98						
G2001	29.5	13.803	.468	11.500	16.70	4.46	13.	1.5	3.5	.479	9.27
G2002	28.5	13.680	.480	12.831	6.21						
G2003	29.	14.026	.483	13.102	6.59						
G2004	29.	14.033	.484	13.452	4.14						
G2005	26.	12.488	.480	10.900	12.71						
†H2001	31.	15.644	.504	15.005	4.08	3.02	16.	2.	4.25	.494	4.15
†H2002	29.9	14.800	.495	14.213	3.97						
†H2003	30.	14.830	.494	14.290	3.64						
†H2004	30.8	15.040	.488	14.327	4.74						
†H2005	28.	13.723	.490	13.128	4.33						
B2101	27.	11.142	.412	9.030	18.93	3.24	17.	3.	1.0	.411	13.12
B2102	27.	11.262	.417	9.632	14.49						
B2103	27.3	11.128	.407	9.776	12.16						
B2104	27.	11.195	.415	10.112	9.68						
B2105	26.6	10.800	.406	9.633	10.34						
C2101	27.	10.737	.397	9.541	11.12	4.72	17.	3.	1.	.411	7.58
C2102	27.5	11.103	.403	10.215	8.01						
C2104	28.	12.117	.432	11.680	3.61						
D2101	26.8	10.890	.407	10.206	6.29	4.16	16.	2.5	1.5	.406	4.44
D2102	27.	11.101	.411	10.617	4.36						
D2105	27.8	11.137	.401	10.840	2.67						
E2101	28.7	11.478	.400	10.871	5.28	4.46	14.	3.	2.	.421	6.62
E2102	28.4	11.983	.422	11.237	6.24						
E2103	28.	12.115	.432	11.233	7.27						
E2104	27.8	12.030	.433	11.193	6.96						
E2105	26.7	11.193	.419	10.374	7.33						
F2101	29.	12.187	.419	11.765	3.47	2.48	15.	2.5	2.25	.432	2.88
F2102	29.	12.570	.433	12.427	1.14						
F2103	28.	12.527	.447	11.952	4.59						
F2104	27.9	12.543	.449	12.086	3.64						
F2105	26.4	10.909	.413	10.741	1.54						
G2101	30.	13.586	.453	12.760	6.09	3.84	16.	3.25	3.	.437	7.90
G2102	29.	12.250	.422	11.077	9.59						
G2103	28.8	12.390	.429	11.350	8.40						
G2104	30.	12.790	.426	11.703	8.50						
G2105	28.	12.340	.441	11.485	6.93						
H2101	30.	12.601	.420	11.580	8.11	4.20	16.	3.	3.	.426	7.09
H2102	28.2	11.976	.424	11.300	5.65						
H2103	28.	11.865	.424	11.090	6.54						
H2104	29.	12.255	.422	11.300	7.8						
H2105	27.	11.905	.441	11.030	7.35						

† Partially sap-wood.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Loblolly pine (*Pinus Taeda*)											
*B2201	26.5	12.598	.475	10.566	16.14	2.28	28.	2.5	4.5	.471	13.84
*B2202	28.7	13.677	.476	11.594	15.24						
*B2203	28.	13.250	.473	11.525	13.02						
*B2204	28.	12.925	.462	11.379	11.96						
*B2205	28.	13.166	.470	11.478	12.82						
*C2201	26.	12.629	.485	12.059	4.51	2.28	28.	2.5	5.	.476	15.93
*C2202	29.2	13.860	.475	11.931	13.91						
*C2203	28.5	13.560	.476	11.073	18.35						
*C2204	27.5	12.874	.468	8.693	32.50						
*C2205	27.	12.904	.478	11.567	10.37						
*D2202	29.8	13.686	.459	8.647	36.85	3.32	24.	3.	5.75	.462	40.75
*D2203	28.4	13.194	.464	7.023	46.80						
*D2205	28.	13.294	.474	8.156	38.60						
*E2201	25.	12.432	.497	11.806	5.04	2.8	26.	3.	5.5	.486	4.73
*E2202	27.5	13.409	.487	12.904	3.77						
*E2203	26.	12.764	.491	12.350	3.24						
*E2204	26.	12.310	.474	11.651	5.35						
*E2205	26.2	12.690	.484	11.895	6.26						
*F2201	26.5	13.672	.516	9.384	31.40	3.1	26.	4.	6.25	.508	38.3
*F2202	28.	14.115	.504	8.330	40.9						
*F2203	27.	13.623	.504	7.103	47.9						
*F2204	28.	14.169	.506	8.840	37.6						
*F2205	28.	14.250	.509	9.426	33.9						
*G2201	28.	14.466	.517	9.206	36.4	2.38	32.	5.	6.75	.513	10.48
*G2202	28.	14.360	.513	13.869	3.42						
*G2203	27.5	14.281	.519	13.811	3.29						
*G2204	26.2	13.510	.516	12.906	4.47						
*G2205	26.	12.985	.499	12.358	4.84						
*H2201	28.2	16.306	.578	10.781	33.9	2.8	32.	6.5	7.	.558	27.47
*H2202	28.3	16.004	.566	10.687	33.22						
*H2203	27.9	15.405	.552	11.750	23.75						
*H2204	27.5	15.022	.546	11.174	25.60						
*H2205	26.8	14.697	.548	11.629	20.90						
†B2301	30.7	15.465	.504	14.644	5.31	3.28	15.	2.75	2.75	.503	4.97
†B2302	30.	15.046	.502	14.286	5.05						
†B2303	30.	15.534	.518	14.978	3.58						
†B2304	30.	15.545	.518	14.640	5.82						
†B2305	29.7	14.013	.472	13.296	5.12						
C2301	31.5	17.449	.554	16.461	5.66	6.7	15.	1.5	2.75	.549	5.03
C2302	30.	16.705	.556	15.760	5.66						
C2303	30.	17.373	.579	16.446	5.33						
C2304	30.	16.980	.566	15.996	5.97						
C2305	29.	14.239	.491	13.875	2.56						
†D2302	29.7	13.145	.442	9.598	27.	2.36	15.	2.	3.5	.450	29.40
†D2304	28.	13.016	.465	7.935	39.02						
†D2305	27.4	12.126	.443	9.436	22.20						
*E2303	27.5	13.909	.506	10.885	21.75	.92	25.	3.	4.25	.494	32.41
*E2304	27.	13.767	.510	7.700	44.1						
*E2305	26.	12.086	.465	8.294	31.4						
*F2301	27.5	12.383	.450	10.785	12.91	3.22	25.	3.	3.75	.481	17.99
*F2302	27.	12.245	.454	10.744	12.26						
*F2303	26.9	13.717	.510	11.890	13.3						
*F2304	26.5	13.550	.511	12.033	11.2						
*F2305	26.3	12.690	.482	7.586	40.3						

* Sap-wood.
† Partially sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Loblolly pine (*Pinus Taeda*)											
*G2302	26.2	14.456	.552	12.777	11.61	2.38	30.	3.5	4.5	.534	11.40
*G2304	27.8	14.556	.523	12.685	12.87						
*G2305	25.4	13.395	.527	12.094	9.72						
*E2402	26.	12.095	.465	10.111	16.42	2.92	24.	2.75	3.75	.458	25.64
*E2403	26.6	12.300	.463	9.930	19.28						
*E2404	26.4	12.087	.458	8.257	31.75						
*E2405	25.2	11.401	.453	7.398	35.10						
*G2401	26.	12.711	.489	8.721	31.4	4.4	27.	5.5	4.5	.479	30.16
*G2402	26.3	12.630	.480	8.502	32.63						
*G2403	26.5	12.814	.484	9.637	24.8						
*G2404	26.5	12.575	.475	8.380	33.4						
*G2405	26.	12.159	.467	8.722	28.25						
*H2401	26.	14.490	.556	10.824	25.31	3.12	29.	7.5	5.	.530	23.64
*H2404	24.4	12.670	.519	9.810	22.6						
*H2405	24.4	12.615	.517	9.715	23.						
*C2501	28.	13.547	.484	8.470	37.5	2.8	20.	2.25	4.	.478	25.35
*C2502	26.7	12.740	.477	8.110	36.3						
*C2503	27.	12.749	.472	6.915	45.7						
*C2504	27.9	13.267	.476	12.838	3.23						
*C2505	27.8	13.365	.480	12.828	4.02						
*D2501	26.8	12.770	.476	11.068	13.34	3.18	20.	2.5	4.	.469	19.07
*D2502	26.	12.278	.472	9.480	22.8						
*D2503	25.9	11.973	.462	9.511	20.59						
*D2504	25.9	11.966	.462	9.531	20.37						
*D2505	25.	11.838	.473	9.678	18.25						
*E2501	26.5	12.687	.478	12.400	2.26	3.	25.	2.5	3.5	.461	8.18
*E2502	26.	12.158	.467	11.571	4.84						
*E2503	26.	11.975	.460	11.376	5.01						
*E2505	25.	10.956	.438	8.700	20.6						
*F2501	27.	12.915	.478	10.542	18.37	2.14	23.	2.75	4.25	.468	31.63
*F2502	25.5	12.144	.476	10.907	10.18						
*F2503	25.	11.489	.459	6.438	44.1						
*F2504	25.2	11.784	.467	7.545	36.						
*F2505	24.1	11.134	.462	5.627	49.5						
*H2501	27.	13.557	.502	4.377	67.71	3.26	27.	3.5	4.75	.486	54.82
*H2502	27.	13.305	.493	4.650	65.1						
*H2503	26.3	12.680	.482	6.782	46.5						
*H2504	27.	12.950	.480	5.570	57.						
*H2505	26.	12.388	.476	7.710	37.8						
*B2601	26.5	13.747	.519	10.541	23.33	3.4	35.	7.	5.	.536	23.68
*B2604	27.	14.616	.542	11.073	24.17						
*B2605	26.	14.375	.553	10.990	23.55						
*C2601	27.3	14.103	.517	10.045	28.78	4.5	35.	7.	5.	.520	20.34
*C2602	28.	14.536	.519	11.242	22.65						
*C2603	27.8	14.559	.523	10.796	25.85						
*C2604	28.4	14.680	.517	11.343	22.79						

* Sap-wood.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Loblolly pine (*Pinus Taeda*)											
*C2605	27.9	14.650	.525	14.410	1.64						
*D2601	28.	14.590	.521	9.357	35.9	2.3	35.	7.	5.5	.532	35.02
*D2602	27.	14.427	.534	10.507	27.2						
*D2603	26.8	14.353	.535	9.323	35.04						
*D2604	27.	14.393	.532	8.463	41.2						
*D2605	26.	14.044	.540	9.024	35.78						
*E2601	27.2	14.263	.524	13.594	4.69	2.14	38.	6.	6.	.516	12.27
*E2602	25.8	13.103	.507	12.775	2.50						
*E2603	24.6	12.944	.526	10.994	15.07						
*E2604	24.7	12.615	.510	9.834	22.04						
*E2605	24.	12.273	.512	10.180	17.06						
*F2601	27.5	15.016	.546	10.156	32.36	2.12	40.	6.	6.	.533	22.02
*F2603	27.	14.258	.528	10.538	26.10						
*F2605	26.	13.695	.526	12.655	7.6						
*G2601	27.	14.630	.542	13.495	7.75	2.04	40.	6.	6.	.532	7.68
*G2602	30.	16.350	.545	15.234	6.83						
*G2603	30.	15.905	.530	14.757	7.21						
*G2604	28.	14.613	.522	13.333	8.75						
*G2605	27.5	14.286	.519	13.163	7.87						
*H2601	27.5	14.424	.525	5.394	62.6	2.92	40.	6.	6.5	.509	30.46
*H2602	30.8	15.928	.517	9.672	39.3						
*H2603	30.	15.194	.506	13.425	11.64						
*H2604	28.7	14.303	.498	12.592	11.96						
*H2605	27.9	13.920	.499	10.196	26.78						
†B2701	30.	13.613	.454	11.097	18.47	1.56	20.	3.5	3.25	.476	14.79
†B2703	30.	15.220	.507	13.240	13.00						
†B2704	28.5	13.320	.467	11.600	12.91						
†C2701	30.	13.650	.455	12.365	9.41	1.5	20.	3.75	3.25	.461	19.05
†C2702	29.8	13.406	.450	9.894	26.2						
†C2705	29.5	14.144	.479	11.098	21.55						
*D2703	28.7	14.277	.497	12.931	9.42	1.24	23.	6.	4.	.504	8.86
*D2704	28.	13.855	.495	12.780	7.76						
*D2705	27.5	14.332	.521	12.987	9.39						
*E2701	27.9	14.450	.518	11.901	17.64	1.24	29.	10.5	4.75	.538	14.31
*E2702	27.	14.153	.524	11.485	18.85						
*E2703	28.	15.843	.566	13.882	12.38						
*E2704	27.4	14.833	.542	13.202	11.00						
*E2705	27.	14.638	.542	12.931	11.67						
*F2703	29.	15.087	.520	13.074	13.35	.94	28.	9.	4.25	.513	8.88
*F2704	27.8	14.185	.510	13.046	8.04						
*F2705	27.5	14.003	.509	13.270	5.24						
*G2701	28.5	15.194	.532	14.623	3.76	1.84	30.	14.	5.5	.539	4.39
*G2702	26.4	13.962	.529	13.321	4.59						
*G2705	26.8	14.915	.556	14.194	4.83						
*H2701	28.7	15.730	.549	11.032	29.85	2.48	30.	13.	5.25	.563	19.50
*H2702	27.	14.996	.555	12.759	14.92						
*H2703	26.	14.775	.568	12.115	18.						
*H2704	26.	14.617	.562	11.722	19.8						
*H2705	25.	14.515	.581	12.350	14.91						
*B2801	28.	13.812	.493	9.548	30.8	3.1	25.	2.	3.	.480	34.20
*B2802	27.5	13.515	.491	10.354	23.4						
*B2803	28.3	14.010	.495	8.560	38.9						
*B2804	27.5	12.635	.459	7.037	44.3						
*B2805	27.	12.539	.464	8.324	33.6						

* Sap-wood.
† Partially sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Loblolly pine (*Pinus Taeda*)											
*C2801	27.5	12.985	.471	9.116	29.82	2.36	25.	2.5	3.5	.481	37.61
*C2802	27.	12.926	.478	7.351	43.10						
*C2805	27.	13.369	.495	8.041	39.9						
*D2801	27.	13.173	.487	9.364	28.91	2.22	25.	2.5	3.75	.487	17.35
*D2802	27.	13.136	.486	9.905	24.6						
*D2803	25.	11.947	.478	10.665	10.72						
*D2804	26.	12.973	.499	11.363	12.41						
*D2805	26.8	12.997	.484	11.685	10.10						
*E2801	27.	13.385	.495	12.063	9.90	2.16	27.	2.75	3.75	.502	10.16
*E2802	26.	13.285	.510	11.774	11.39						
*E2803	26.8	13.396	.500	12.164	9.19						
*F2801	27.	13.657	.505	9.381	31.3	2.64	27.	3.	4.5	.494	19.59
*F2802	27.	13.375	.495	10.540	21.2						
*F2803	24.5	11.975	.489	10.590	11.58						
*F2804	27.	13.210	.489	11.003	16.70						
*F2805	26.5	13.012	.491	10.780	17.15						
*G2801	26.8	12.742	.476	11.995	5.86	1.96	27.	3.5	4.5	.480	19.69
*G2802	26.8	12.954	.483	12.122	6.42						
*G2803	27.	14.047	.520	9.177	34.7						
*G2804	26.6	12.660	.476	9.030	38.65						
*G2805	26.	11.622	.447	10.131	12.82						
*H2801	28.	14.021	.501	6.855	51.10	2.06	28.	6.	5.	.493	43.72
*H2804	26.	12.703	.489	6.980	45.10						
*H2805	25.	12.267	.490	7.982	34.95						
*B2905	26.8	12.809	.478	12.180	4.91	1.54	35.	6.25	3.25	.478	4.91
*C2902	25.5	13.288	.521	12.714	4.32	1.92	35.	6.5	3.5	.515	4.27
*C2903	25.5	12.973	.508	12.524	3.46						
*C2905	26.4	13.607	.515	12.924	5.02						
*D2901	28.1	14.340	.510	13.641	4.87	1.12	35.	13.5	4.	.497	8.99
*D2902	29.5	14.551	.493	13.612	6.45						
*D2903	28.5	14.103	.495	11.739	16.76						
*D2904	29.8	14.722	.494	12.982	11.81						
*D2905	28.	13.763	.492	13.066	5.06						
*E2901	26.8	14.070	.525	11.068	21.36	.9	35.	11.	4.25	.520	24.04
*E2902	27.	13.901	.515	10.780	22.45						
*E2903	26.	13.477	.518	9.386	30.39						
*E2904	26.	13.521	.520	9.852	27.16						
*E2905	25.7	13.360	.520	10.842	18.84						
*F2902	25.3	14.189	.560	13.200	6.97	.66	35.	10.	4.5	.562	3.46
*F2904	24.4	13.869	.568	13.516	2.55						
*F2905	24.6	13.710	.557	13.592	.86						
*G2901	26.	15.537	.597	14.661	5.64	.72	32.	7.5	4.25	.579	4.21
*G2902	26.	15.143	.582	14.220	6.09						
*G2903	25.	14.277	.571	13.784	3.45						
*G2904	25.	14.450	.578	13.970	3.32						
*G2905	25.	14.157	.566	13.795	2.56						

* Sap-wood.

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Loblolly pine (*Pinus Taeda*)											
*H2901	25.	13.835	.554	13.098	5.33	.82	35.	12.5	5.	.570	5.90
*H2902	24.	13.643	.569	12.887	5.54						
*H2903	24.	13.675	.570	12.835	6.15						
*H2904	24.	13.844	.577	13.104	5.34						
*H2905	22.5	13.038	.580	12.105	7.16						
†B3001	30.	13.835	.461	13.200	4.59	1.08	22.	3.5	3.5	.456	8.93
†B3002	29.8	13.297	.446	12.750	4.12						
†B3003	29.8	13.384	.449	12.821	4.21						
†B3004	29.8	13.625	.457	11.648	14.5						
†B3005	28.6	13.400	.468	11.092	17.23						
†C3001	30.	13.430	.447	10.818	19.42	1.76	22.	3.5	3.5	.451	12.05
†C3002	30.	13.395	.446	11.937	10.88						
†C3003	31.5	14.128	.448	12.793	9.45						
†C3004	32.5	14.605	.449	13.749	5.86						
†C3005	32.	14.860	.464	12.686	14.62						
†D3001	30.	13.038	.434	10.212	21.70	2.76	25.	4.	4.25	.441	11.47
†D3004	30.	12.925	.431	11.959	7.47						
†D3005	29.5	13.555	.459	12.845	5.24						
*E3001	29.	14.045	.484	13.368	4.82	2.4	27.	10.	5.	.489	4.40
*E3002	27.	13.330	.494	12.800	3.97						
*F3001	29.3	13.493	.460	10.775	20.15	1.84	26.	7.	4.5	.471	27.66
*F3002	30.5	13.940	.457	10.511	24.56						
*F3003	30.4	14.005	.461	10.423	25.57						
*F3004	29.5	14.186	.480	10.711	24.51						
*F3005	28.	13.909	.497	7.856	43.51						
*G3001	30.	15.523	.517	9.399	39.44	2.5	29.	10.5	5.25	.512	37.0
*G3003	30.	15.357	.512	9.941	35.26						
*G3004	29.9	15.193	.507	9.681	36.30						
*H3001	27.8	14.414	.518	12.454	13.60	1.84	30.	16.	5.75	.522	17.01
*H3002	28.	14.705	.525	12.640	14.04						
*H3003	26.8	13.930	.520	11.137	20.03						
*H3004	27.	13.876	.514	10.856	21.80						
*H3005	26.	13.864	.533	11.701	15.60						
Longleaf pine (*Pinus palustris*)											
F3101	27.4	17.293	.630	17.280	.08	3.44	45.	26.	4.75	.641	1.01
F3102	27.3	17.644	.646	17.642	.01						
F3103	28.	18.427	.658	18.424	.02						
F3104	26.4	17.030	.645	16.722	1.81						
F3105	25.7	16.058	.625	15.552	3.15						
G3101	30.	18.890	.629	18.879	.06	4.26	45.	35.	4.5	.645	.03
G3102	29.8	18.299	.614	18.292	.04						
G3103	27.5	19.820	.721	19.814	.03						
G3104	29.	18.270	.630	18.268	.01						
G3105	26.8	16.980	.634	16.977	.02						
I 3101	29.8	19.350	.649	19.346	.02	6.02	45.	24.	5.5	.649	.11
I 3102	30.	19.550	.651	19.502	.25						
I 3103	30.4	19.916	.655	19.880	.18						
I 3104	29.8	19.050	.639	19.037	.07						
I 3105	28.	18.306	.653	18.298	.04						
J 3103	29.2	20.756	.711	20.755	.004	10.28	45.	24.	5.5	.709	.23
J 3104	29.4	20.746	.706	20.690	.27						
J 3105	28.	19.827	.711	19.757	.35						
K3101	29.5	19.864	.674	19.860	.02	15.7	45.	25.	5.75	.680	.88

* Sap-wood.
† Partially sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
K3102	28.7	19.737	.688	19.735	.01						
K3103	27.9	19.267	.691	18.970	1.54						
K3104	27.8	18.798	.675	18.640	.84						
K3105	27.8	18.749	.674	18.372	2.01						
M3101	30.3	22.250	.734	20.235	9.05	18.4	48.	25.	6.5	.726	9.09
M3102	30.	22.372	.746	20.072	10.3						
M3103	31.3	22.802	.728	20.780	8.87						
M3104	30.8	21.827	.708	19.903	8.81						
M3105	29.	20.764	.716	19.011	8.45						
N3101	29.	22.083	.761	20.100	8.98	22.26	48.	24.	6.5	.797	13.20
N3102	30.3	24.323	.802	21.670	10.91						
N3103	32.4	26.543	.819	22.441	15.46						
N3104	30.8	24.906	.809	21.129	15.16						
N3105	28.8	22.926	.796	19.368	15.51						
A3201	29.9	17.684	.591	17.684	.00	3.78	40.	6.5	2.	.605	1.04
A3202	30.	17.873	.596	17.872	.01						
A3203	29.	17.515	.604	16.606	5.19						
A3204	29.	17.903	.617	17.902	.01						
A3205	27.	16.618	.616	16.618	.00						
D3201	25.	15.476	.619	15.181	1.91	5.7	40.	10.	3.	.616	.67
D3202	28.7	17.530	.611	17.290	1.37						
D3203	27.	16.505	.611	16.500	.03						
D3204	27.	16.940	.627	16.937	.02						
D3205	27.8	17.068	.614	17.064	.02						
E3201	27.5	17.029	.619	17.019	.06	4.1	40.	9.	3.	.613	.06
E3202	30.3	18.857	.622	18.842	.08						
E3203	29.8	17.896	.600	17.892	.02						
E3204	30.5	18.799	.616	18.787	.06						
E3205	28.5	17.369	.610	17.352	.10						
F3201	25.8	16.508	.640	15.794	4.33	16.7	38.	10.	3.5	.676	7.62
F3202	30.	19.858	.662	18.557	6.55						
F3203	27.	19.175	.710	17.565	8.4						
F3204	27.5	18.841	.685	17.152	8.96						
F3205	28.	19.163	.684	17.272	9.87						
J 3203	28.	16.655	.595	14.593	12.4	4.2	36.	10.	4.	.600	8.11
J 3204	28.	16.930	.604	15.839	6.45						
J 3205	27.	16.276	.602	15.383	5.49						
K3201	26.	14.925	.574	14.454	3.16	9.72	35.	9.	4.5	.592	2.81
K3202	30.	17.190	.573	16.818	2.16						
K3203	27.4	15.723	.574	15.350	2.37						
K3204	27.6	16.666	.604	16.198	2.81						
K3205	28.5	18.179	.637	17.532	3.56						
L3201	28.	18.458	.659	17.980	2.59	22.52	35.	9.	5.	.725	4.80
L3202	30.	20.440	.681	19.745	2.42						
L3203	30.	21.297	.710	20.193	5.19						
L3204	31.5	24.330	.772	22.820	6.21						
L3205	29.5	23.791	.806	21.980	7.61						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
O3201	30.	24.556	.818	21.673	12.76	23.74	35.	10.5	5.5	.834	11.78
O3202	29.	24.151	.832	20.791	13.91						
O3203	27.5	22.610	.822	19.601	13.30						
O3204	28.	24.030	.859	21.652	9.89						
O3205	26.8	22.456	.838	20.417	9.07						
B3301	28.4	18.516	.652	18.516	.00	3.7	30.	12.	5.	.619	.004
B3302	28.	17.000	.607	17.000	.00						
B3303	30.4	18.610	.612	18.609	.01						
B3304	31.8	19.364	.608	19.362	.01						
D3301	26.3	16.579	.630	15.969	3.68	2.06	30.	18.	5.25	.605	3.12
D3302	25.3	15.957	.631	15.442	3.23						
D3303	26.7	16.280	.609	15.734	3.35						
D3304	27.5	16.434	.597	15.965	2.85						
D3305	27.	15.038	.557	14.665	2.48						
E3301	29.5	17.493	.592	15.421	11.85	15.56	25.	23.	5.75	.644	9.91
E3303	27.8	17.637	.634	16.596	5.91						
E3304	28.	18.720	.669	17.030	9.03						
E3305	27.6	18.775	.680	16.363	12.85						
I 3302	26.8	17.818	.665	17.792	.15	32.06	45.	14.	6.75	.773	5.22
I 3303	28.	20.116	.718	19.489	3.12						
I 3304	26.5	21.835	.824	20.526	5.98						
I 3305	27.	23.958	.887	21.433	10.55						
J 3301	27.7	16.610	.600	14.077	15.23	4.08	45.	14.	6.75	.593	3.08
J 3302	24.4	14.590	.597	14.587	.02						
J 3303	25.5	15.014	.589	15.000	.09						
J 3304	26.3	15.483	.589	15.479	.03						
J 3305	26.5	15.643	.590	15.638	.03						
L3301	27.	27.050	1.002	23.357	13.63	10.66	45.	12.5	7.	.901	13.18
L3302	25.	23.714	.949	20.202	14.81						
L3303	24.8	22.151	.894	18.822	15.03						
L3304	24.	20.916	.871	18.272	12.65						
L3305	23.	18.218	.792	16.434	9.79						
N3301	28.	15.893	.567	15.890	.02	2.62	45.	15.	7.5	.568	4.61
N3302	30.	17.250	.575	17.205	.26						
N3303	29.2	16.198	.554	16.198	.00						
N3304	28.3	16.190	.572	16.187	.02						
N3305	30.7	17.640	.575	13.627	22.78						
P3302	26.	26.006	1.000	22.112	14.98	20.58	45.	20.	8.00	.993	16.26
P3304	25.8	26.252	1.017	21.633	17.60						
P3305	24.	23.113	.963	19.365	16.21						
C3401	22.8	17.830	.619	17.350	2.69	5.58	32.	15.	2.5	.627	3.21
C3402	28.	17.525	.626	16.936	3.36						
C3403	28.	17.572	.627	16.914	3.75						
C3404	30.	18.843	.628	18.239	3.20						
C3405	31.	19.780	.638	19.170	3.08						
D3401	29.	18.446	.636	17.772	3.65	1.9	35.	18.	3.25	.633	4.18
D3402	28.	17.824	.636	17.010	4.56						
D3405	29.	18.500	.638	17.676	4.45						
H3401	28.	16.474	.588	16.271	1.23	2.0	40.	24.	4.	.592	8.84
H3402	27.	16.217	.601	16.102	.71						
H3403	27.	15.802	.586	15.756	.29						
H3404	26.4	15.540	.589	15.342	1.27						
H3405	25.2	15.017	.596	14.879	.92						
L3401	25.	14.814	.592	14.687	.86	1.86	40.	31.	4.5	.595	1.52
L3402	25.7	15.260	.594	15.042	1.43						
L3403	26.	15.467	.594	15.193	1.77						

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
L3404	26.	15.518	.597	15.241	1.79						
L3405	25.3	15.160	.599	14.896	1.74						
N3401	26.	15.030	.578	14.911	.79	3.22	35.	26.	5.25	.571	.83
N3402	25.8	14.584	.563	14.576	.05						
N3403	26.	14.926	.570	14.886	.27						
N3404	26.7	15.449	.567	15.323	.82						
N3405	26.	15.070	.579	14.737	2.21						
P3401	28.	15.274	.545	14.871	2.64	3.62	40.	27.	6.	.556	1.42
P3402	27.	14.887	.551	14.686	1.35						
P3403	28.	15.528	.519	15.373	1.00						
P3404	28.2	16.030	.569	16.030	.00						
P3405	28.8	17.179	.596	16.816	2.12						
E3501	26.8	17.096	.638	16.166	5.44	1.74	50.	42.	3.5	.645	2.84
E3502	25.7	16.519	.643	15.635	5.35						
E3503	25.5	16.265	.637	15.726	3.31						
E3504	26.	16.882	.649	16.863	.11						
E3505	25.	16.479	.659	16.478	.01						
G3501	26.	15.960	.614	15.566	2.47	2.94	50.	45.	4.	.610	.83
G3502	25.3	15.251	.602	15.250	.01						
G3505	24.5	15.065	.615	15.062	.02						
H3501	29.	18.383	.634	17.956	2.32	1.18	50.	38.	4.	.635	.77
H3504	28.7	18.292	.637	18.292	.00						
H3505	26.7	16.947	.635	16.947	.00						
K3502	27.	17.030	.631	17.030	.00	3.28	50.	38.	4.5	.633	1.54
K3503	27.	16.927	.627	16.481	2.63						
K3504	28.	17.960	.642	17.602	1.99						
M3501	27.5	19.235	.699	18.210	5.33	10.66	50.	37.	5.75	.689	3.04
M3502	28.	19.198	.685	18.522	3.52						
M3503	26.7	18.456	.691	17.939	2.80						
M3504	26.6	18.331	.689	18.021	1.69						
M3505	25.4	17.365	.684	17.042	1.86						
N3501	27.5	20.375	.740	19.893	2.37	11.04	50.	38.	5.5	.709	1.77
N3502	27.	20.110	.745	19.541	2.82						
N3503	26.	18.710	.720	18.412	1.59						
N3504	26.6	19.071	.617	18.988	.44						
N3505	26.	18.800	.722	18.490	1.65						
A3601	30.7	24.280	.791	21.479	11.53	29.48	27.5	19.	3.5	.786	10.7
A3602	30.3	24.455	.806	21.915	10.39						
A3603	30.7	24.100	.785	21.712	9.91						
A3604	31.	23.946	.772	21.225	11.39						
A3605	32.1	24.962	.777	22.400	10.28						
B3601	26.8	18.468	.689	17.638	4.5	14.72	40.	15.	4.	.696	2.91
B3602	26.8	18.566	.694	17.851	3.85						
B3603	28.	19.719	.704	19.200	2.63						
B3604	28.	19.665	.702	19.206	2.33						
B3605	28.4	19.704	.694	19.457	1.25						
C3601	26.3	21.420	.815	19.865	7.26	13.38	55.	13.	5.	.824	6.21

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
C3602	26.5	22.230	.839	20.520	7.69						
C3603	27.	22.930	.849	21.411	6.62						
C3604	27.5	22.797	.829	21.538	5.54						
C3605	27.5	21.698	.789	20.837	3.97						
G3601	28.	20.250	.723	16.940	16.35	7.06	50.	13.	5.5	.709	15.79
G3602	26.5	18.866	.712	16.391	13.12						
G3605	26.3	18.230	.693	14.965	17.9						
†L3601	27.8	17.840	.642	16.475	7.64	7.4	37.5	16.	6.25	.630	13.23
†L3602	27.8	17.457	.628	15.305	12.32						
†L3603	28.7	17.868	.622	15.761	11.80						
†L3604	27.	16.886	.625	13.483	20.19						
†L3605	27.	17.170	.636	14.731	14.20						
†M3601	27.	17.856	.661	15.319	14.20	5.9	30.	17.	6.5	.664	21.10
†M3602	28.	18.507	.661	16.376	11.51						
†M3603	28.7	19.310	.672	13.649	29.30						
†M3604	28.5	19.159	.672	14.165	26.06						
†M3605	29.	19.080	.657	14.415	24.44						
*N3601	29.9	15.604	.522	12.610	19.19	10.7	31.	13.	7.	.538	26.62
*N3602	29.9	15.506	.519	11.651	24.82						
*N3603	30.2	16.057	.532	8.766	45.40						
*N3604	30.	16.370	.546	12.526	23.50						
*N3605	30.5	17.485	.573	13.960	20.2						
* P3601	30.	13.230	.441	9.215	30.35	7.02	20.	20.	7.75	.442	7.31
* P3602	30.	13.327	.444	12.991	2.52						
* P3603	30.	13.253	.441	13.039	1.62						
* P3604	30.8	13.607	.442	13.440	1.23						
* P3605	30.2	13.360	.442	13.248	.84						
B3701	29.8	17.610	.591	17.565	.26	23.64	25.	10.	1.5	.646	1.98
B3702	28.7	18.122	.631	17.945	.98						
B3703	29.	18.740	.646	18.512	1.22						
B3704	30.5	20.200	.662	19.830	1.83						
B3705	28.5	19.957	.700	19.290	3.34						
I 3701	27.8	16.138	.580	14.530	9.96	2.44	31.	12.	3.25	.607	12.58
I 3704	29.8	19.221	.645	17.188	10.58						
I 3705	30.	17.890	.596	14.809	17.22						
L3703	27.8	15.665	.564	14.996	4.26	2.78	30.	10.	4.	.565	5.37
L3704	28.6	16.210	.566	14.848	8.4						
L3705	26.	14.704	.566	14.195	3.46						
M3701	31.	18.390	.593	15.900	13.55	2.96	32.	9.	4.75	.593	13.86
M3702	31.3	18.576	.593	17.597	5.26						
M3703	29.	17.184	.592	15.330	10.8						
M3704	28.7	17.065	.595	12.116	29.						
M3705	27.	15.952	.591	14.246	10.7						
P3701	31.8	18.372	.577	18.372	.00	2.28	32.	9.	4.5	.574	8.41
P3702	31.	17.886	.576	17.886	.00						
P3703	28.	16.118	.575	15.236	5.47						
P3704	28.	16.207	.579	10.697	34.						
P3705	26.	14.696	.565	14.316	2.58						
A3801	29.	20.248	.698	20.244	.02	2.9	46.	8.5	2.5	.673	3.09
A3802	30.	20.037	.668	20.003	.17						
A3803	30.2	20.145	.667	20.132	.06						
A3804	32.	21.459	.671	19.554	8.87						
A3805	32.	21.093	.660	19.756	6.33						
B3801	30.	18.587	.619	17.994	3.19	3.02	45.	.9	3.5	.613	9.17

* Sap-wood.
† Partially sap-wood.

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
B3802	31.	19.006	.614	17.868	5.98						
B3803	30.5	18.366	.603	16.501	10.15						
B3804	33.2	20.227	.609	17.979	11.11						
B3805	32.	19.840	.620	16.776	15.45						
D3801	29.	19.544	.674	18.371	6.00	8.62	46.	9.	4.	.674	5.63
D3802	28.8	19.012	.660	17.833	6.19						
D3803	27.9	18.460	.662	17.477	5.33						
D3804	27.8	18.486	.665	17.392	5.93						
D3805	27.	19.230	.712	18.321	4.72						
F3801	28.	20.262	.724	19.016	6.14	3.38	47.	10.5	4.5	.658	4.92
F3802	30.5	19.981	.655	18.690	6.46						
F3803	29.	18.695	.644	17.969	3.89						
F3804	30.9	19.660	.636	18.882	3.96						
F3805	30.	19.007	.633	18.220	4.14						
H3801	28.	20.730	.740	18.932	8.67	15.5	47.	8.5	4.75	.704	7.94
H3802	28.	20.115	.718	18.292	9.06						
H3803	27.	18.803	.696	17.332	7.83						
H3804	26.8	18.317	.683	16.917	7.64						
H3805	28.	19.225	.686	17.974	6.51						
M3801	28.	22.965	.820	21.023	8.46	8.58	48.	9.5	5.5	.738	6.81
M3802	28.	21.016	.751	19.511	7.16						
M3803	26.	18.640	.717	17.392	6.69						
M3804	27.	19.245	.713	18.102	5.94						
M3805	26.	17.961	.691	16.921	5.79						
O3801	28.	28.248	1.010	23.045	18.40	23.98	50.	17.	6.25	.976	16.28
O3802	28.	28.182	1.010	23.221	17.62						
O3803	27.	27.052	1.002	21.930	18.94						
O3804	29.6	28.065	.948	23.044	17.89						
O3805	27.8	25.366	.911	23.200	8.56						
P3801	27.8	26.544	.955	22.770	14.22	22.6	52.	16.	7.	.928	15.82
P3802	28.	26.683	.954	23.308	12.62						
P3803	28.4	26.650	.939	21.258	20.21						
P3804	29.4	26.914	.915	21.944	18.48						
P3805	29.5	25.845	.876	22.326	13.60						
A3901	27.7	17.330	.625	17.330	.00	20.08	28.	10.	2.	.667	1.79
A3904	28.5	18.930	.664	18.570	1.9						
A3905	28.1	20.070	.714	19.372	3.48						
B3901	27.9	20.510	.735	19.661	4.14	36.18	30.	10.	2.75	.799	6.07
B3902	28.5	22.433	.787	21.051	6.16						
B3903	28.5	23.019	.808	21.836	5.14						
B3904	29.7	24.240	.816	22.491	7.21						
B3905	28.	23.847	.851	22.002	7.73						
E3901	27.4	26.679	.974	23.106	13.39	30.08	38.	20.	3.5	.903	12.15
E3903	28.	25.675	.917	22.180	13.6						
E3905	27.	22.059	.817	19.971	9.46						
H3901	26.	27.032	1.039	23.431	13.31	37.02	50.	22.	4.25	1.063	12.21
H3902	26.8	28.330	1.057	24.552	13.33						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
H3903	28.	29.800	1.067	26.112	12.38						
H3904	27.7	29.724	1.076	26.683	10.23						
H3905	28.	30.216	1.079	26.646	11.80						
I 3901	28.	26.815	.958	22.723	15.25	26.86	51.	21.	4.25	.904	13.17
I 3902	26.7	25.195	.943	21.786	13.54						
I 3905	26.	21.134	.813	18.870	10.72						
K3901	27.	25.058	.928	22.974	8.32	10.44	50.	15.	4.75	.832	4.79
K3902	27.	23.628	.875	22.153	6.24						
K3903	26.	21.450	.825	20.630	3.82						
K3904	26.	20.386	.783	19.550	4.11						
K3905	26.	19.497	.750	19.213	1.46						
O3901	28.	28.175	1.006	25.150	10.75	19.74	52.	20.	5.75	.833	15.29
O3902	27.2	25.771	.946	20.276	21.35						
O3903	26.	21.048	.810	18.511	12.02						
O3904	26.	19.033	.732	16.373	13.99						
O3905	26.	17.623	.678	14.395	18.32						
P3901	29.8	27.638	.926	24.425	11.61	12.28	54.	16.	6.25	.690	18.03
P3902	29.	19.186	.661	14.775	23.01						
P3905	30.8	14.858	.482	11.097	19.46						
A4001	30.	18.060	.602	17.304	4.18	7.48	30.	10.	2.	.617	5.49
A4004	30.	18.672	.622	17.500	6.28						
A4005	28.5	17.827	.626	16.754	6.02						
F4002	27.	16.550	.613	16.546	.02	6.34	33.	25.	3.75	.616	.024
F4004	28.	17.287	.616	17.285	.01						
F4005	26.	16.093	.619	16.087	.04						
G4001	28.	16.583	.592	16.250	2.01	4.96	33.	29.	4.25	.599	5.52
G4002	27.	16.088	.596	15.850	1.48						
G4003	27.	16.108	.597	14.853	7.79						
G4004	27.4	16.769	.612	15.370	8.34						
G4005	26.2	15.707	.600	14.451	7.99						
I 4001	27.8	16.317	.586	14.542	10.88	8.38	36.	24.	4.75	.582	8.22
I 4002	26.7	15.659	.586	14.635	6.55						
I 4003	27.	15.734	.583	14.565	7.41						
I 4004	27.9	16.138	.578	14.071	12.81						
I 4005	27.5	15.814	.575	15.270	3.44						
N4001	27.5	17.892	.577	17.300	3.31	7.16	36.	30.	5.	.567	2.04
N4002	27.	17.333	.567	16.726	3.50						
N4003	26.9	16.440	.562	16.433	.04						
N4004	27.2	16.892	.565	16.795	.57						
N4005	26.	15.689	.564	15.255	2.77						
O4001	29.	16.884	.561	16.643	1.43	9.74	34.	30.	5.5	.561	1.88
O4002	28.	16.680	.560	16.050	3.78						
O4003	28.	15.830	.551	15.803	.17						
O4004	29.	17.625	.574	17.106	2.94						
O4005	28.	16.884	.560	16.705	1.06						
A4101	32.	15.940	.482	15.888	.33	22.76	6.	7.	0.00	.506	.83
A4102	31.	16.627	.504	16.361	1.60						
A4103	31.	16.148	.489	16.057	.56						
A4104	32.	17.638	.520	17.440	1.01						
A4105	29.7	16.300	.535	16.190	.68						
B4101	30.	17.715	.590	16.600	6.29	11.8	20.	9.	1.0	.596	4.74
B4102	30.	17.866	.595	17.845	.12						
B4103	29.8	17.500	.587	16.553	5.41						
B4104	31.5	19.092	.605	18.064	5.38						
B4105	30.	18.155	.605	16.976	6.49						
C4101	29.	17.780	.612	17.353	2.40	11.38	20.	9.	1.0	.615	2.44

TABLE I (Continued)

DECAY OF YELLOW PINE INDUCED BY LENZITES SAEPIARIA

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Culture block	Volume (cc.)	Weight before decay (gm.)	Specific gravity	Weight after decay (gm.)	Per cent loss in weight due to decay	Per cent resin	Per cent summer wood	Number growth rings per inch	Inches from pith	Average specific gravity	Average per cent loss in weight
Longleaf pine (*Pinus palustris*)											
C4102	29.5	18.624	.631	17.930	3.72						
C4103	30.	18.805	.627	18.233	3.04						
C4104	32.5	19.830	.610	19.394	2.20						
C4105	31.5	18.760	.595	18.600	.85						
D4101	27.	15.403	.571	15.400	.02	13.92	22.	10.	1.0	.623	2.63
D4104	27.5	17.442	.634	17.345	.56						
D4105	26.	17.295	.664	16.031	7.31						
E4101	28.4	15.665	.552	14.286	8.80	12.52	25.	10.	1.5	.561	5.16
E4102	29.1	15.751	.541	15.021	4.64						
E4103	28.	15.390	.549	14.705	4.45						
E4104	27.	15.345	.568	14.693	4.25						
E4105	25.9	15.410	.595	14.847	3.65						
F4101	27.	15.182	.544	14.979	1.34	23.08	25.	10.	1.5	.545	.78
F4102	28.5	15.883	.546	15.814	.44						
F4103	28.	15.455	.541	15.318	.89						
F4104	28.	15.585	.538	15.410	1.12						
F4105	28.	15.883	.556	15.867	.10						
G4101	27.6	16.492	.586	16.409	.50	11.02	27.	9.	2.	.592	1.17
G4102	27.9	16.669	.590	16.578	.55						
G4103	26.5	16.810	.596	16.233	3.44						
G4104	27.5	16.888	.584	16.702	1.10						
G4105	28.2	17.820	.603	17.775	.25						
I 4101	27.	14.857	.532	14.707	1.01	16.84	25.	9.5	2.25	.560	1.21
I 4102	27.	14.964	.536	14.886	.52						
I 4103	26.4	14.801	.545	14.732	.47						
I 4104	30.8	17.420	.565	17.102	1.83						
I 4105	29.8	18.600	.624	18.184	2.24						
J 4101	26.8	14.689	.557	13.480	8.23	7.6	25.	9.	2.25	.561	8.63
J 4102	27.	15.080	.558	13.700	9.16						
J 4103	26.	14.657	.564	13.506	7.86						
J 4104	29.5	16.753	.567	15.200	9.28						
K4102	26.	14.220	.547	14.017	1.43	3.52	25.	9.	2.5	.538	3.45
K4103	25.4	13.706	.539	12.840	6.32						
K4104	29.4	15.366	.523	14.487	5.72						
K4105	27.	15.704	.582	15.650	.34						
L4102	28.4	16.117	.567	15.312	4.99	5.96	28.	13.	3.	.564	4.87
L4103	27.	15.248	.565	14.467	5.12						
L4104	31.4	17.327	.552	16.444	5.09						
L4105	29.	16.557	.571	15.850	4.27						
M4101	27.8	17.405	.626	17.314	.52	8.92	28.	14.	3.25	.566	.70
M4102	27.7	15.529	.561	15.521	.05						
M4103	26.	14.267	.549	14.085	1.28						
M4104	28.5	15.870	.556	15.611	1.63						
M4105	26.	14.062	.541	14.057	.04						
N4101	26.	15.367	.591	14.632	4.78	9.52	28.	13.	3.5	.595	3.15
N4102	26.	15.388	.592	14.630	4.93						
N4103	24.8	14.685	.592	14.401	1.94						

TABLE I (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Longleaf pine (*Pinus palustris*)											
N4104	27.8	16.667	.599	16.380	1.72						
N4105	24.	14.440	.602	14.107	2.30						
O4101	28.	15.747	.562	15.629	.75	19.64	27.	14.	3.5	.571	1.25
O4102	27.2	15.350	.564	15.146	1.33						
O4103	27.3	15.206	.557	15.052	1.01						
O4104	26.7	14.760	.553	14.497	1.78						
O4105	26.	16.090	.619	15.872	1.36						
P4101	32.	18.390	.574	18.327	.34	7.84	27.	13.	3.75	.577	2.88
P4102	30.	17.556	.585	16.705	4.85						
P4104	30.	17.182	.572	16.592	3.44						
B4201	27.8	18.073	.650	17.752	1.78	22.34	30.	18.	1.00	.667	1.43
B4202	29.	18.772	.647	18.416	1.90						
B4203	31.	22.690	.699	22.092	2.64						
B4204	30.	19.760	.658	19.652	.55						
B4205	31.	21.799	.683	21.735	.29						
F4201	26.6	16.505	.620	16.076	2.60	9.54	30.	16.	2.25	.617	.88
F4203	28.	17.156	.613	17.150	.04						
F4205	28.3	17.524	.619	17.522	.01						
G4201	30.	19.192	.639	16.943	11.72	4.84	30.	16.	2.75	.645	8.70
G4203	31.	20.127	.649	18.811	6.54						
G4205	31.3	20.241	.647	18.650	7.86						
K4201	24.3	14.983	.616	14.893	.60	4.94	32.	15.	3.25	.603	.68
K4202	25.	14.884	.595	14.778	.71						
K4203	27.	16.130	.597	16.011	.74						
K4204	26.	15.718	.604	15.644	.47						
K4205	27.	16.344	.605	16.198	.89						
L4201	28.3	18.238	.645	18.235	.02	3.52	32.	23.	4.	.648	5.14
L4202	28.6	18.918	.661	18.912	.03						
L4203	26.8	17.523	.654	16.410	6.35						
L4204	25.8	16.528	.641	15.206	8.00						
L4205	24.8	15.860	.640	14.072	11.28						
N4201	28.	18.013	.643	17.047	5.36	4.30	32.	29.	4.	.628	1.79
N4204	26.7	16.541	.619	16.540	.01						
N4205	27.	16.838	.624	16.835	.02						
O4201	28.	17.052	.609	16.220	4.88	3.24	25.	24.	3.75	.598	8.80
O4202	28.	16.808	.600	15.703	6.57						
O4203	26.	15.432	.594	14.600	5.39						
O4204	26.2	15.662	.597	13.630	12.98						
O4205	25.6	15.186	.593	13.027	14.21						
P4202	27.	16.302	.604	13.810	15.28	5.6	25.	30.	4.5	.590	10.30
P4204	25.2	14.797	.587	12.485	15.61						
P4205	25.4	14.732	.580	14.730	.01						

SERIES B

In this series lettered columns of blocks chosen from the same samples of longleaf, shortleaf, and loblolly pine as employed in series A, were used. Five culture blocks were used in each column of blocks, and numbers 1 and 5 were left in their natural condition, while from 2, 3, and 4 the resin was extracted. The blocks were all labeled as described above, and those from which the resin was to be extracted were

placed in a large 3-liter flask containing benzol. To this flask was connected a reflux condensor, and the benzol boiled. The benzol was changed from time to time until no resin was obtained when 100 cc. of the benzol in which the blocks had boiled for 10 hours was distilled. These resin-free culture blocks were then placed in an electric oven and dried for 10 days at 65° C. Cultures were prepared in the same way as in series A, and the controls and the resin-free blocks were segregated. All were inoculated with *Lenzites saepiaria*. The results obtained are given in table II. The percentage of loss in weight of the resin-free blocks, of course, is based on the weight of the blocks after the resin was extracted. The results of the experiment are very striking, for on the average the percentage loss in weight is greater in the control blocks containing resin than in the resin-free blocks. It may be that the vigorous and continued boiling in benzol had such an effect on the lignin as to prevent decay. However, in series C where the blocks were soaked in benzol for a few hours the benzol seemed to have no such effect on the growth of the fungus. On the other hand, it may be that benzol dissolves out other substances which aid in the nutrition of fungi within the woody tissues. Time has not permitted a repetition of series B, and until such is done we hesitate to place much stress on this phase of the work.

TABLE II (Series B)

EFFECT ON THE GROWTH OF LENZITES SAEPIARIA OF EXTRACTING BENZOL-SOLUBLE SUBSTANCES FROM YELLOW PINE WOOD

I	II	III	IV	V	VI	VII	VIII	IX
Longleaf pine (*Pinus palustris*)			Shortleaf pine (*Pinus echinata*)			Loblolly pine (*Pinus Taeda*)		
Culture block	Per cent loss in weight	Per cent resin	Culture block	Per cent loss in weight	Per cent resin	Culture block	Per cent loss in weight	Per cent resin
H3101	3.52	16.68	A4301	3.22	3.74	A2001	10.04	17.4
H3102	0.04	0.0	A4302	0.32	0.0	A2002	0.02	0.0
H3103	0.14	0.0	A4303	0.41	0.0	A2003	0.02	0.0
H3104	0.04	0.0	A4304	0.06	0.0	A2004	0.09	0.0
H3105	6.42	16.68	A4305	3.81	3.74	A2005	7.56	17.4
G3201	1.85	24.48	B4301	3.24	4.08	A2101	2.28	3.28
G3202	0.88	0.0	B4302	0.40	0.0	A2102	2.92	0.0
G3203	0.15	0.0	B4303	0.89	0.0	A2103	2.93	0.0
G3204	0.95	0.0	B4304	0.02	0.0	A2104	4.82	0.0

TABLE II (Continued)

I	II	III	IV	V	VI	VII	VIII	IX
Longleaf pine (*Pinus palustris*)			Shortleaf pine (*Pinus echinata*)			Loblolly pine (*Pinus Taeda*)		
G3205	6.21	24.48	B4305	3.12	4.08	A2105	2.3	3.28
P3201	9.19	22.26	C4401	6.64	3.94	A2201	29.9	6.4
P3202	0.13	0.0	C4402	1.20	0.0	A2202	2.74	0.0
P3203	0.91	0.0	C4403	1.23	0.0	A2203	3.52	0.0
P3204	0.27	0.0	C4404	3.29	0.0	A2204	2.91	0.0
P3205	8.06	22.26	C4405	5.04	3.94	A2205	16.15	6.4
F3301	8.70	5.78	F4401	2.64	3.58	A2301	24.3	18.56
F3302	1.60	0.0	F4402	0.02	0.0	A2302	2.78	0.0
F3303	3.36	0.0	F4403	0.03	0.0	A2303	2.72	0.0
F3305	7.48	5.78	F4404	0.09	0.0	A2304	3.73	0.0
O3401	0.03	5.50	F4405	2.18	3.58	A2305	29.0	18.56
O3402	0.80	0.0	D4501	4.22	3.66	H2301	11.93	3.08
O3403	0.41	0.0	D4502	1.23	0.0	H2302	2.47	0.0
O3404	0.39	0.0	D4503	1.62	0.0	H2303	3.10	0.0
O3405	0.60	5.50	D4504	1.58	0.0	H2304	4.06	0.0
L3501	0.06	5.8	D4505	4.83	3.66	H2305	9.39	3.08
L3502	0.33	0.0	F4501	2.39	3.84	D2401	8.74	4.68
L3503	0.40	0.0	F4502	1.56	0.0	D2402	7.09	0.0
L3504	0.49	0.0	F4503	3.39	0.0	D2403	5.51	0.0
L3505	0.28	5.8	F4504	1.27	0.0	D2404	5.68	0.0
H3601	6.74	15.72	F4505	6.86	3.84	D2405	6.24	4.68
H3602	0.92	0.0	.....	.....	.....	F2401	13.00	5.00
H3603	1.26	0.0	.....	.....	.....	F2402	0.64	0.0
H3604	1.33	0.00	.....	.....	.....	F2403	1.05	0.0
H3605	4.96	15.72	.....	.....	.....	F2404	0.41	0.0
O3701	3.94	3.96	.....	.....	.....	F2405	8.83	5.00
O3702	2.10	0.0	.....	.....	.....	A2501	41.8	7.28
O3703	1.28	0.0	.....	.....	.....	A2502	0.02	0.0
O3704	2.68	0.0	.....	.....	.....	A2503	0.01	0.0
O3705	3.23	3.96	.....	.....	.....	A2504	1.25	0.0
E3801	13.5	25.58	.....	.....	.....	A2505	47.3	7.28
E3802	1.61	0.0	.....	.....	.....	A2601	9.47	5.10
E3803	0.81	0.0	.....	.....	.....	A2602	0.02	0.0
E3804	0.04	0.0	.....	.....	.....	A2603	1.03	0.0
E3805	12.93	25.58	.....	.....	.....	A2604	7.30	0.0
G3901	14.67	15.16	.....	.....	.....	A2605	9.97	5.10
G3902	5.46	0.0	.....	.....	.....	A2701	3.49	3.36
G3903	0.27	0.0	.....	.....	.....	A2702	0.02	0.0
G3904	0.50	0.0	.....	.....	.....	A2703	0.01	0.0
G3905	10.36	15.16	.....	.....	.....	A2704	0.06	0.0
P4001	5.04	5.78	.....	.....	.....	A2705	5.20	3.36
P4002	0.37	0.0	.....	.....	.....	A2801	7.83	10.5
P4003	0.41	0.0	.....	.....	.....	A2802	0.03	0.0
P4004	1.40	0.0	.....	.....	.....	A2803	0.01	0.0
P4005	7.21	5.78	.....	.....	.....	A2804	0.48	0.0
H4101	3.03	4.70	.....	.....	.....	A2805	12.70	10.5
H4102	0.35	0.0	.....	.....	.....	A2901	6.10	3.72
H4103	0.44	0.0	.....	.....	.....	A2902	0.05	0.0
H4104	0.23	0.0	.....	.....	.....	A2903	0.06	0.0
H4105	25.80	4.7	.....	.....	.....	A2904	0.11	0.0
E4201	11.58	4.52	.....	.....	.....	A2905	7.68	3.72
E4202	0.99	0.0	.....	.....	.....	A3001	3.18	4.18
E4203	1.98	0.0	.....	.....	.....	A3002	0.03	0.0
E4204	0.35	0.0	.....	.....	.....	A3003	0.07	0.0
E4205	25.15	4.52	.....	.....	.....	A3004	0.02	0.0
.....	.....	.....	.....	.....	.....	A3005	2.88	4.18

SERIES C

For this series blocks of yellow poplar (*Liriodendron tulipifera*) were cut the same size as for the cultures of series A and B. They were all taken from the same piece of sap-wood and were all of approximately the same specific gravity. They were dried to constant weight at 65° C. and weighed. Twelve dilutions of resin in benzol were prepared, containing from 0 to 10 per cent resin. Seven of the blocks were immersed in each of these resin solutions, which were heated to boiling to drive the air out of the blocks. When the solution had cooled it was driven into the blocks, impregnating them with various amounts of resin. The blocks were then removed to an electric oven where they remained at room temperature for several hours, while a greater part of the benzol evaporated, after which they were dried at 65° C. and weighed. Control blocks without resin were also used and all were placed in cultures as described for series A. All were inoculated with *Lenzites saepiaria* and were incubated for one year.

TABLE III (Series C)

DECAY OF RESIN-IMPREGNATED YELLOW POPLAR BLOCKS INDUCED BY LENZITES SAEPIARIA

Culture block	Weight before decay (gm.)	Weight after decay (gm.)	Per cent loss in weight	Per cent resin
O 1	12.093	7.894	34.70	*0
O 2	11.360	9.777	13.95	*0
O 3	12.636	10.916	13.60	*0
O 4	11.525	10.690	7.25	*0
O 5	11.193	9.182	17.96	*0
O 6	13.793	10.915	20.87	*0
O 7	13.451	8.517	36.70	*0
P 1	13.007	8.276	36.40	0.87
P 2	13.085	8.012	38.80	0.74
P 3	9.636	5.161	46.50	0.27
P 4	10.888	8.009	26.40	0.27
P 5	10.236	6.692	34.63	0.03
P 6	11.827	7.257	38.70	0.17
P 7	13.581	8.750	35.50	0.41
Q 1	13.181	8.706	33.95	0.88
Q 2	12.710	9.545	24.90	0.57
Q 3	11.785	8.765	25.60	0.00
Q 4	10.075	8.226	18.35	0.50
Q 5	11.400	8.675	23.90	0.43
Q 6	11.393	8.845	22.40	0.54
Q 7	13.208	8.521	35.50	0.48
R 1	13.153	9.580	27.15	0.29

* Soaked in benzene without resin.

TABLE III (Continued)

Culture block	Weight before decay (gm.)	Weight after decay (gm.)	Per cent loss in weight	Per cent resin
R 2	10.532	8.187	22.30	1.99
R 3	12.695	9.552	24.80	1.47
R 4	13.286	10.048	24.40	1.73
R 5	12.792	10.531	17.70	0.31
R 6	13.911	10.136	27.15	1.39
R 7	10.858	7.840	27.8	0.00
S 1	13.058	9.550	26.9	1.76
S 2	11.250	10.594	5.83	2.38
S 3	11.442	8.888	22.34	2.10
S 4	13.199	11.871	10.07	2.19
S 5	12.332	11.576	6.14	1.64
S 6	10.680	10.275	3.79	2.13
S 7	11.323	10.630	6.13	2.00
T 1	13.290	9.148	31.15	2.85
T 2	13.117	8.844	32.60	3.17
T 3	12.509	9.488	24.15	2.80
T 4	13.404	9.746	27.30	2.41
T 5	12.274	7.450	39.30	3.48
T 6	12.693	10.631	16.25	2.75
T 7	14.344	8.779	38.80	3.07
U 1	12.983	12.053	7.18	0.92
U 2	13.397	12.363	7.72	2.59
U 3	14.073	13.596	3.39	5.18
U 4	13.320	12.139	8.87	6.55
U 5	13.051	12.120	7.14	3.23
U 6	12.269	10.901	11.15	1.79
U 7	11.283	8.425	25.30	2.25
V 1	11.832	8.055	31.94	4.04
V 2	12.215	9.500	22.25	4.30
V 3	14.045	9.448	32.70	3.29
V 4	10.814	8.317	23.10	1.85
V 5	11.465	7.518	34.50	4.52
V 6	11.511	8.946	22.30	5.20
V 7	12.435	7.368	40.70	1.66
W 1	11.384	7.352	35.40	7.18
W 2	12.190	8.411	31.00	6.52
W 3	11.007	9.530	13.40	5.67
W 4	11.773	9.677	17.80	6.02
W 5	11.302	10.165	10.06	7.11
W 6	14.147	7.790	45.00	5.25
W 7	14.572	7.582	48.00	5.33
X 1	13.154	8.177	37.80	7.55
X 2	11.942	8.554	28.30	5.25
X 3	11.652	7.565	35.00	3.49
X 4	11.603	9.376	19.20	7.84
X 5	12.320	8.205	33.40	5.56
X 6	11.874	9.497	20.00	7.82
X 7	12.695	7.791	38.60	6.07
Y 1	13.594	8.646	36.40	8.45
Y 2	15.290	10.744	29.70	7.80
Y 3	13.248	9.624	27.30	7.21
Y 4	12.915	10.770	16.60	6.76
Y 5	11.224	9.424	16.00	9.33
Y 6	13.502	7.515	44.40	10.18
Y 7	13.032	7.158	45.10	8.30
Z 1	15.685	9.021	42.60	8.28
Z 2	12.785	7.480	41.50	13.62

TABLE III (Continued)

DECAY OF RESIN-IMPREGNATED YELLOW POPLAR BLOCKS INDUCED BY LENZITES SAEPIARIA

Culture block	Weight before decay (gm.)	Weight after decay (gm.)	Per cent loss in weight	Per cent resin
Z 3	11.889	8.855	25.50	12.34
Z 4	13.368	6.485	51.50	11.64
Z 5	12.561	7.268	42.10	10.45
Z 6	14.133	8.060	43.00	10.84
Z 7	14.838	8.407	43.40	8.18
YZ 1	12.032	10.806	10.20	† 0
YZ 2	12.320	11.400	7.46	† 0
YZ 3	13.230	11.983	9.41	† 0
YZ 4	10.642	9.716	8.70	† 0
YZ 5	10.259	9.515	7.25	† 0
YZ 6	10.923	10.135	7.21	† 0
YZ 7	12.005	10.220	14.90	† 0

† Not treated with benzene.

SERIES D

Series D was prepared in exactly the same way as series C, but the cultures were inoculated with *Polystictus hirsutus*, a fungus usually found on hard woods. The incubation period was one year. Table IV shows the results of this series.

TABLE IV (Series D)

DECAY OF RESIN-IMPREGNATED YELLOW POPLAR BLOCKS INDUCED BY POLYSTICTUS HIRSUTUS

Culture block	Weight before decay (gm.)	Weight after decay (gm.)	Per cent loss in weight	Per cent resin
O 8	14.052	13.800	1.79	* 0
O 9	12.166	11.892	2.25	* 0
O 10	10.844	10.585	2.38	* 0
O 11	10.817	10.636	1.67	* 0
O 12	11.164	11.972	1.72	* 0
O 13	13.265	13.001	1.99	* 0
O 14	12.253	11.942	2.53	* 0
P 8	11.248	10.607	5.69	0.11
P 9	12.246	10.275	16.09	0.51
P 10	11.612	9.538	17.85	0.66
P 11	12.944	10.398	19.68	0.31
P 12	10.957	8.563	21.82	0.60
P 13	10.109	9.422	6.80	0.47
P 14	11.611	9.170	21.02	0.83
Q 8	12.776	10.020	21.58	0.38
Q 9	10.770	8.992	16.50	0.64
Q 10	11.067	8.940	19.24	0.69
Q 11	10.330	8.949	13.37	0.58
Q 12	11.386	8.750	23.15	0.97
Q 13	11.107	8.075	27.29	1.10
Q 14	12.150	10.048	17.30	1.22

* Soaked in benzene without resin.

TABLE IV (Continued)

Culture block	Weight before decay (gm.)	Weight after decay (gm.)	Per cent loss in weight	Per cent resin
R 8	12.994	11.022	15.17	1.27
R 9	12.493	10.507	15.90	0.10
R 10	11.285	9.830	12.89	1.28
R 11	11.305	9.360	17.20	0.57
R 12	11.653	8.770	24.76	1.30
R 13	12.434	10.425	16.15	0.11
R 14	10.879	10.651	2.10	1.43
S 8	10.247	6.955	32.10	2.74
S 9	10.375	7.821	24.60	2.15
S 10	12.270	8.438	31.22	1.79
S 11	12.630	9.010	38.62	1.92
S 12	11.584	7.853	32.21	2.65
S 13	11.209	7.071	36.90	2.76
S 14	12.030	8.891	26.10	3.20
T 8	13.401	10.001	25.38	3.22
T 9	12.187	9.220	24.40	3.62
T 10	12.577	9.393	25.40	2.42
T 11	13.520	10.812	20.01	4.01
T 12	12.872	9.905	23.07	2.71
T 13	11.840	10.002	15.51	4.95
T 14	12.154	10.360	14.78	3.09
U 8	13.237	11.027	16.70	2.22
U 9	14.046	11.003	21.70	3.26
U 10	13.068	10.637	18.60	2.55
U 11	12.331	9.530	22.73	1.86
U 12	11.520	8.257	28.35	1.20
U 13	12.288	9.445	23.18	2.25
U 14	12.846	10.031	21.90	3.02
V 8	13.093	10.160	22.40	2.39
V 9	13.070	10.210	21.90	5.36
V 10	11.779	8.510	27.80	3.70
V 11	10.624	8.785	17.30	3.68
V 12	15.300	11.336	25.90	2.45
V 13	14.252	11.200	24.40	4.13
V 14	13.279	9.970	25.00	3.52
W 8	12.064	10.506	12.90	6.12
W 9	14.508	11.836	18.40	5.55
W 10	13.722	11.175	18.58	5.62
W 11	11.527	8.844	23.26	6.00
W 12	11.205	8.366	25.33	6.50
W 13	11.682	9.560	18.16	7.20
W 14	10.651	8.140	23.60	6.16
X 8	12.661	10.466	17.30	9.60
X 9	13.936	9.530	31.60	2.16
X 10	13.444	10.223	23.99	4.73
X 11	10.970	9.066	17.38	6.05
X 12	11.648	9.148	21.45	7.24
X 13	13.160	10.820	17.80	5.06
X 14	13.179	10.690	18.90	4.56
Y 8	13.708	12.330	10.03	8.44
Y 9	14.807	11.843	20.01	7.88
Y 10	12.500	10.541	15.68	10.80
Y 11	12.582	9.957	20.90	7.95
Y 12	13.010	10.926	16.02	7.53
Y 13	12.685	9.587	24.42	9.60
Y 14	13.702	11.294	17.60	8.05
Z 8	15.524	15.402	7.85	8.77

TABLE IV (Continued)

DECAY OF RESIN-IMPREGNATED YELLOW POPLAR BLOCKS INDUCED BY POLYSTICTUS HIRSUTUS

Culture block	Weight before decay (gm.)	Weight after decay (gm.)	Per cent loss in weight	Per cent resin
Z 9	12.769	12.731	0.30	12.41
Z 10	11.781	11.257	4.45	13.20
Z 11	15.329	15.108	1.44	10.40
Z 12	14.727	14.620	0.73	10.50
Z 13	11.832	9.903	16.30	13.48
Z 14	12.035	9.347	22.32	12.34
YZ 8	12.119	10.936	9.76	† 0
YZ 9	10.324	8.931	13.50	† 0
YZ 10	13.698	11.940	12.81	† 0
YZ 11	13.162	11.686	11.20	† 0
YZ 12	11.286	9.660	14.41	† 0
YZ 13	12.073	10.761	10.88	† 0
YZ 14	12.902	11.369	11.90	† 0
YZ 15	10.772	9.436	12.40	† 0

† Not treated with benzene.

Discussion

Before entering upon a discussion of the specific factors of wood which influence its resistance to decay, it might be well to call attention to some factors of the environment which influence fungous activity in general. In a problem of this kind, where the results depend on natural conditions and also to a certain extent on chance or probability of infection, the results may be misleading unless such factors are considered.

In any work where a host is inoculated with an organism one anticipates a certain percentage of failures, even though the host is susceptible and the parasite virulent. The chance of failure of infection seems to be even greater when we deal with the inoculation of woody rather than of more fleshy herbaceous plants; especially is this true when dealing with fungi attacking structural timber. In the cultures of *Lenzites saepiaria* on blocks of yellow pine, described above, the percentage of failure proved to be very high. The charts to be discussed below certainly show this to be a fact. It is true for sap-wood as well as for heart-wood, even though sap-wood decays much more readily than heart-wood. In the same column of blocks of the same sample one culture block may be considerably decayed and others not at all; for instance, in table 1 culture block E 1603 was reduced in weight by decay

only 0.028 per cent, while the adjoining block, E 1604, was reduced 17.5 per cent; also G 1603 was reduced 0.14 per cent and G 1604 was reduced 17.4 per cent. Many other examples in table 1 could be given.

Another discrepancy in the data is the one already mentioned concerning the loss of resin in sterilization. The charts bring out this discrepancy very vividly. Take, for instance, the charts correlating resin content and specific gravity with percentage loss in weight during one year of incubation. If we consider here that a part or all of the loss in weight above 17.6 per cent resin is due to sterilization and that above a specific gravity of .70 to .75 (the average for longleaf pine) the extra weight is due to an excess of resin, the charts will at once show the error due to sterilization. In the general chart showing the relation of specific gravity to the percentage reduction in weight this is more evident than in the other charts. In this chart the values of the specific gravity are marked off on the primary ordinate, and the percentages of reduction in weight on the primary abscissa. As the specific gravity increases above .70 to .75 the curve formed by the plotted points gradually swings away from the primary ordinate. An examination of representative samples in this part of the chart reveals the fact that they have not been attacked in the least by the fungus. We are safe, then, to assume that, as far as loss of weight due to decay is concerned, the plotted points in this part of the chart can be moved over toward the primary ordinate.

Thus, these two factors, (1) the chance of failure of infection and (2) the loss of weight of highly resinous blocks due to sterilization, must be considered when attempting to draw conclusions from the various charts.

CHARTS BASED ON THE RESULTS OF SERIES A

In the charts plotted from the data obtained in series A the three species of pine are distinguished by symbols described in the keys of the various charts. A bar drawn through any of these symbols represents sap-wood.

In all of these charts (I–IX), except chart IV, showing the relation of specific gravity to decay, each point represents an average for a column of culture blocks in the original samples. It was necessary to take these averages in cases where one of the factors concerned was a property of the whole column of blocks, such as resin content, percentage of summer wood, number of rings per inch, etc. In chart IV each point represents an individual culture block.

Resin as an index of durability.—Chart I shows the relation of the resin content of the wood to its decay. The percentages of resin are given on the primary ordinate and the percentages of loss in weight in one year on the primary abscissa. This chart shows two definite facts: (1) Sap-wood decays in all three species irrespective of resin content. The maximum resin content for sap-wood, however, was but 12.9 per cent with a loss in weight of about 13 per cent. (2) In the heart-wood the resin content has no definite relation to resistance in any one of the three species of pine. If there is any relation to be recognized, however, it is apparent above 12 per cent resin, and even here both shortleaf and longleaf pine are reduced in weight 12.5 per cent. Even though the reduction in the upper part of the chart (above 18 per cent resin) may be due entirely to sterilization, the curve below that would be very steep, in fact, practically parallel to the ordinate.

Specific gravity as an index of durability.—Betts ('15) has shown that the density of pine wood depends upon the proportion of summer wood and spring wood in the annual growth rings. "In tests made on a number of small pieces of summer wood and spring wood whittled out separately from wide-ring pieces of loblolly pine, the . . . density of the summer wood came very close to being just twice that of the spring wood, so that the percentage of summer wood in the annual rings is an indication of weight."

Chart II shows very clearly that the specific gravity of the samples used in this work depends upon the percentage of summer wood. On the primary ordinate the values of specific gravity are represented and on the primary abscissa the per-

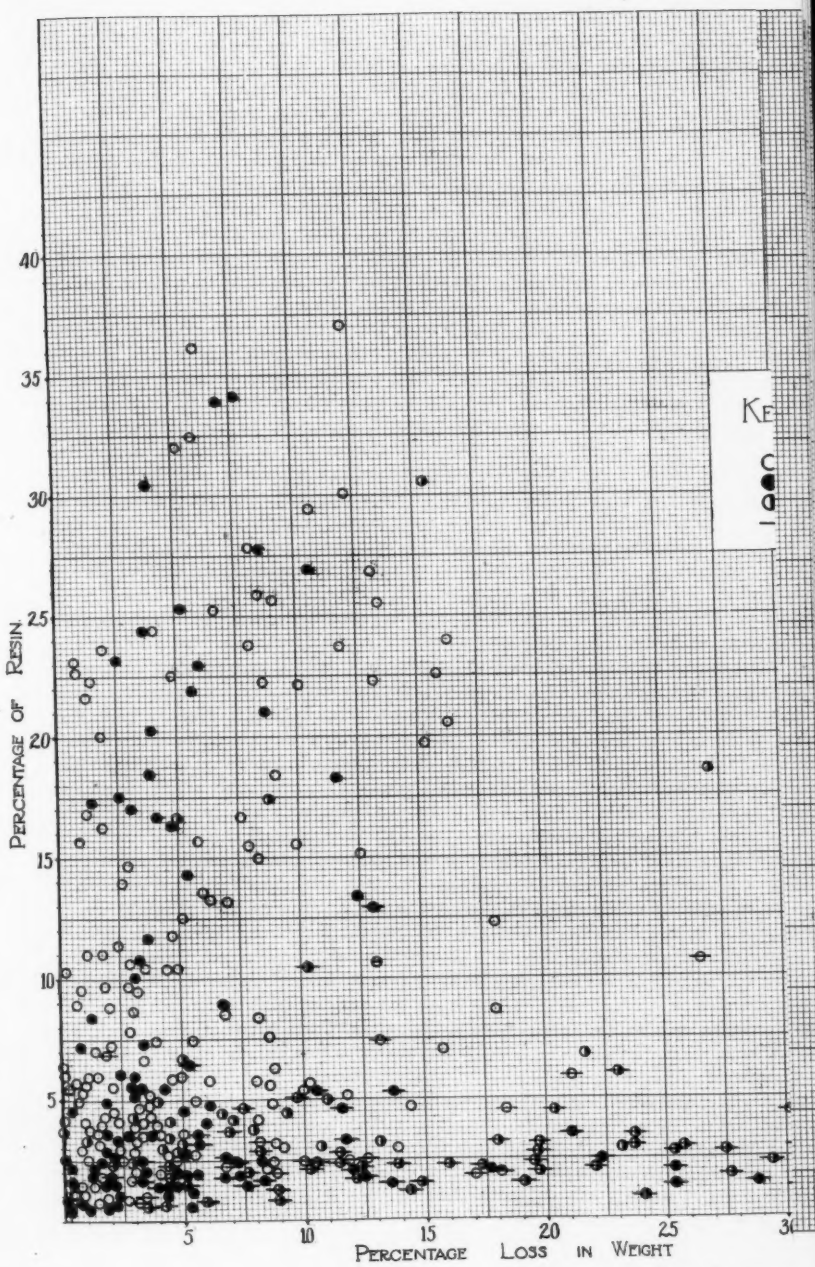


Chart I. Showing the relatic

POUNDS PER CUBIC FOOT	46.8	48.0	53.1	56.2	59.3	62.4	65.6

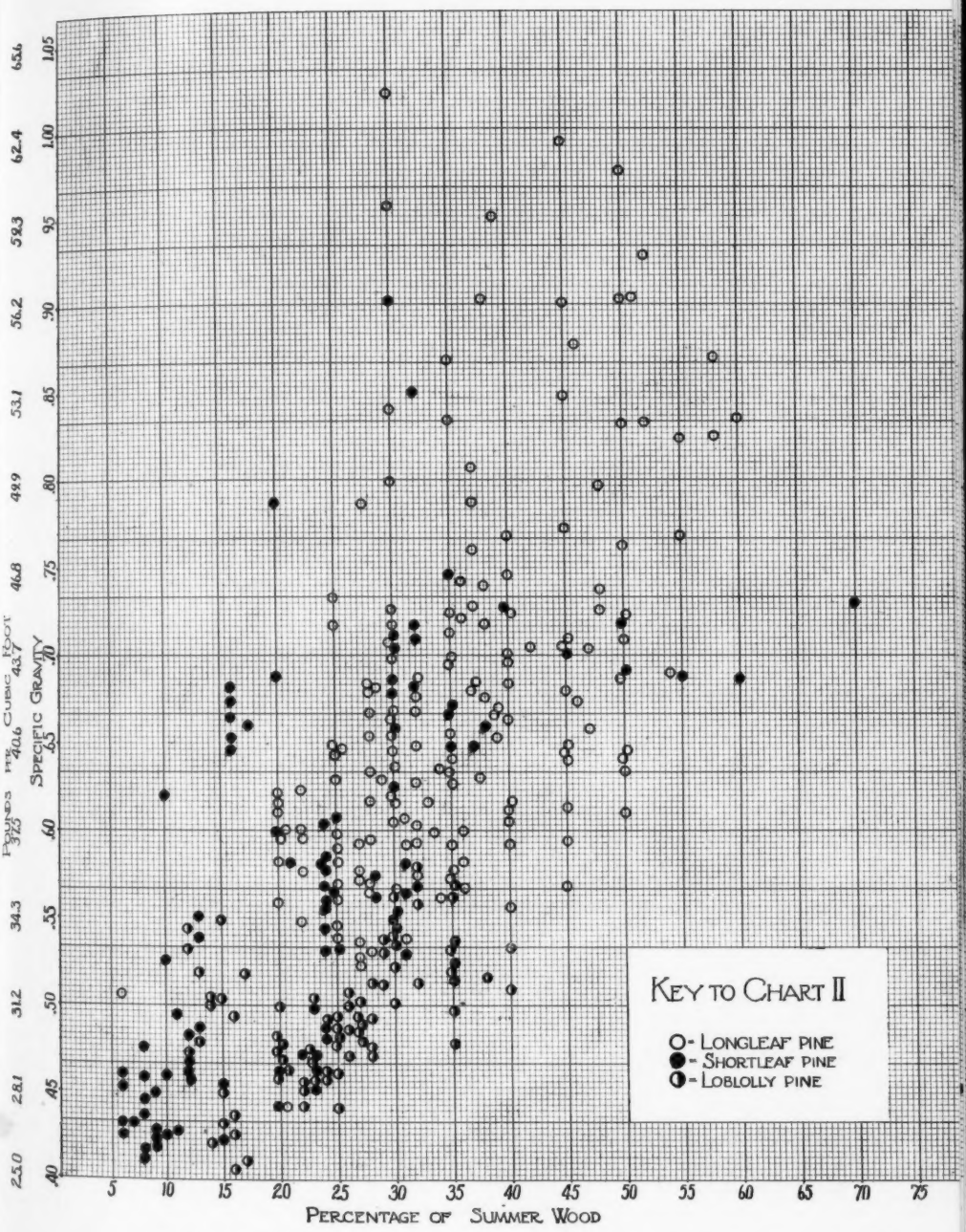


Chart II. Showing that specific gravity depends on the percentage of summer wood.

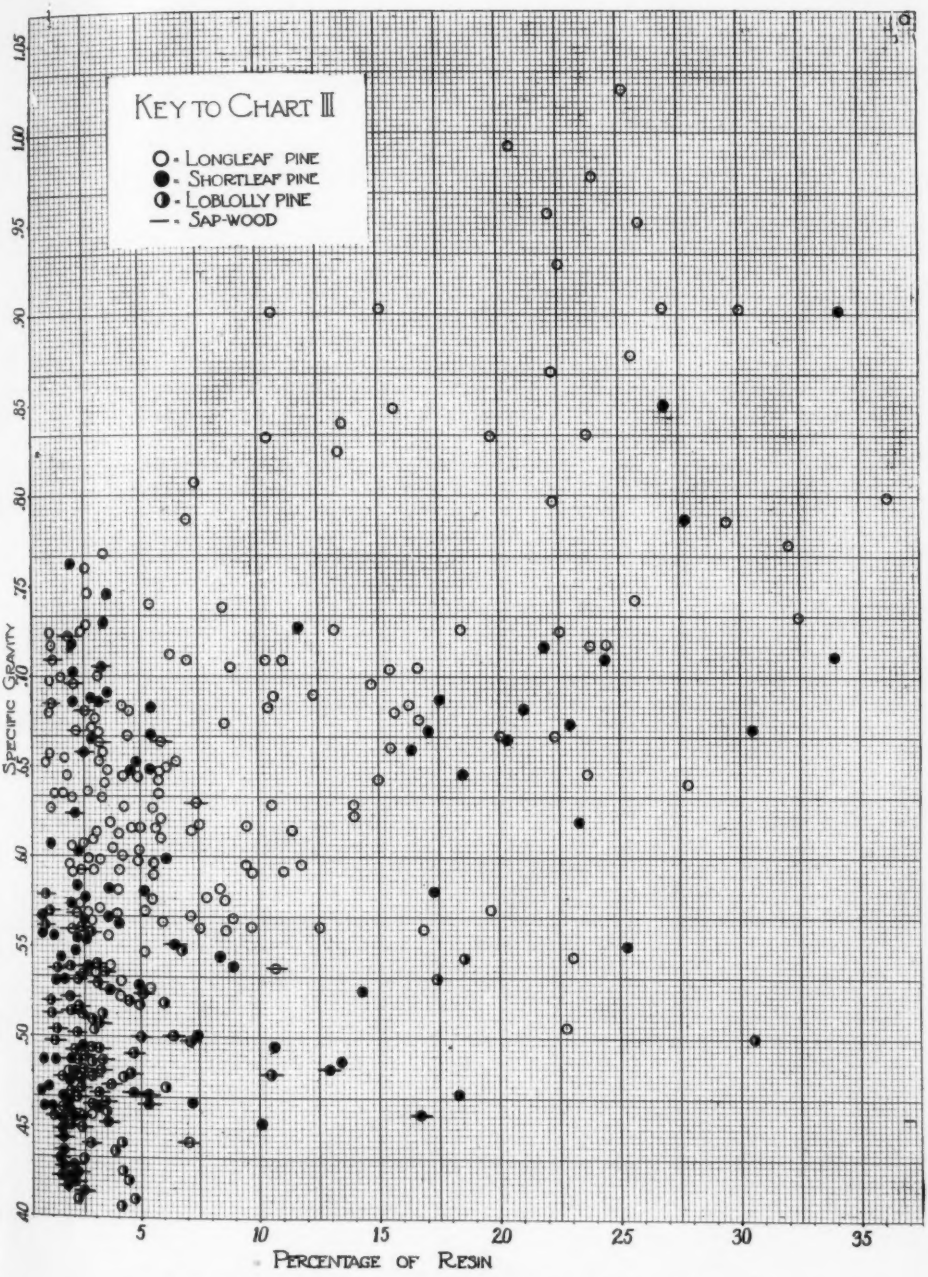


Chart III. Showing the relation of resin content to specific gravity.

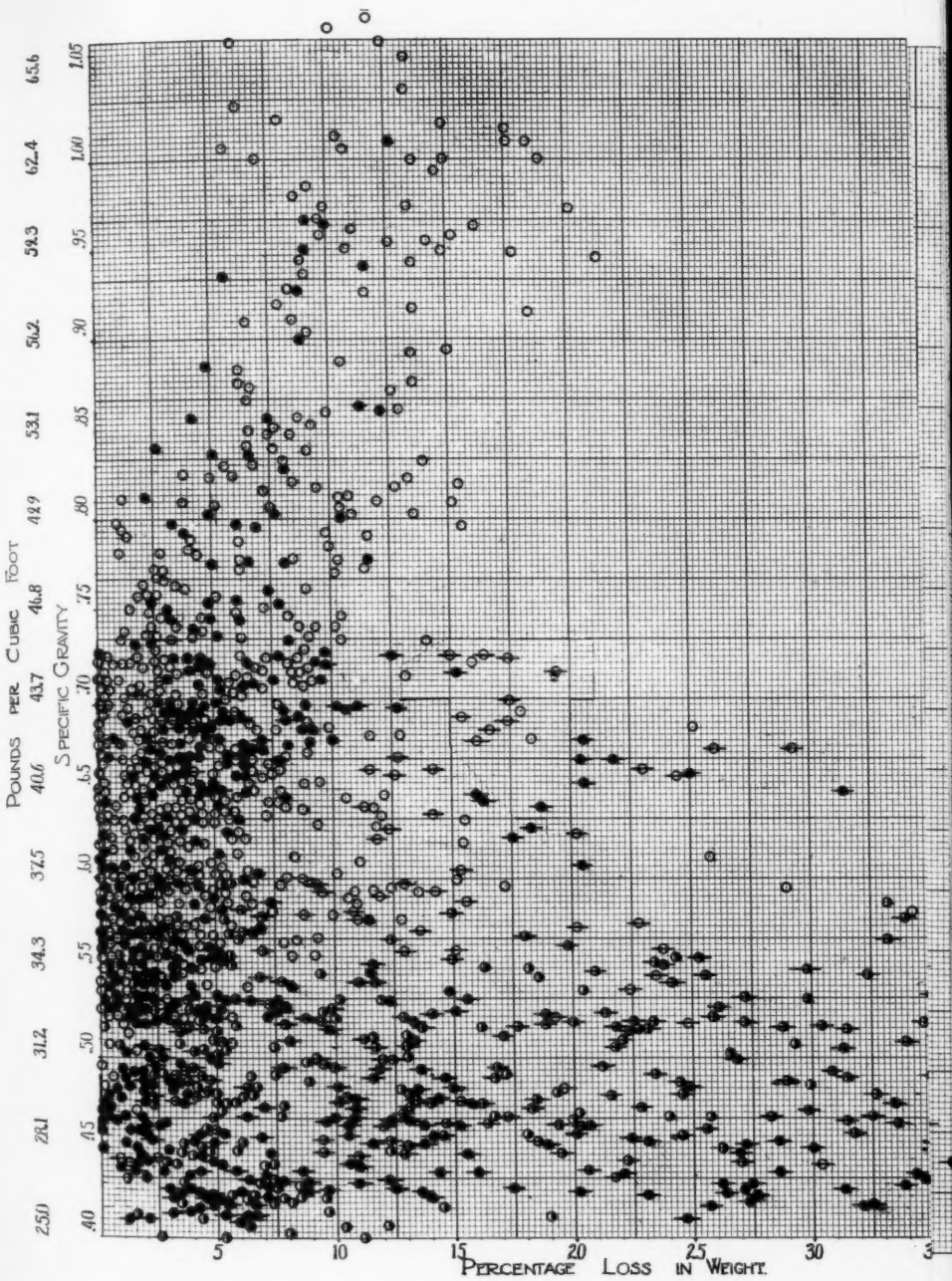


Chart IV. Showing the relation of specific gravity to decay

Chart V. Showing the relation of specific gravity to decay (where

centages of summer wood. As the percentage of summer wood increases the specific gravity increases.

Chart III shows the relation between specific gravity and the percentage of resin. The values of the specific gravity are given on the primary ordinate and the percentages of resin on the primary abscissa. Above a specific gravity of .75 the resin content may influence the weight considerably, but below this weight there seems to be no definite relation in any of the species, the longleaf and shortleaf pine being mixed quite evenly.

Chart IV shows the relation of specific gravity to durability. On the primary abscissa are represented the percentages of loss in weight in one year and on the primary ordinate the values of the specific weights. As was mentioned above, in this case below .75 specific gravity, there is a high percentage of failures in inoculation, and consequently a congestion of plotted points along the primary ordinate in this region. Above .75 specific gravity the curve gradually swings away from the primary ordinate due to the loss of weight in sterilization. Thus, before considering the meaning of this chart it will be necessary to consider this upper portion of the chart with the points moved back toward the primary ordinate.

This chart was plotted on the basis of individual culture blocks, and shows that (1) sap-wood decays irrespective of density or species; (2) there is a perceptible curve showing that irrespective of species the lighter heart-wood decays more readily than the more dense heart-wood; (3) loblolly pine, however, is generally lighter than longleaf and shortleaf pine, the two latter being fairly evenly distributed.

Chart V shows the same relation as illustrated in chart IV, but differs from the latter in that the plotted points represent averages for columns of culture blocks rather than the individual blocks. The general points brought out by this chart are the same as in chart IV, except that the curve for heart-wood becomes more abrupt and the apparent increase of durability due to an increase of density becomes less evident here than in chart IV. However, the specific gravity of pine wood

depends on the percentage of summer wood (chart II) and there is a tendency toward an increase in density with a greater number of growth rings per inch (chart VIII). These two facts, together with the results shown in charts VI and VII, indicate a more evident relation of density to durability than is represented by chart V.

Summer wood as an index of durability.—Chart VI shows the relation of the proportion of pine summer wood and spring wood to resistance to decay. Since density depends on the percentage of summer wood and durability seems to increase with an increase of density, it would be anticipated that with increased summer wood there would be increased decay resistance. Chart VI shows this to be true. A part of the longleaf pine containing between 45 and 55 per cent summer wood was very resinous, and in this chart these points farther out should be considerably thrown back toward the primary ordinate to correct for sterilization.

Chart VI shows that (1) sap-wood decays irrespective of species of pine and also irrespective of summer wood; (2) the summer wood of the heart-wood, on the other hand, shows a tendency to resist decay more than the spring wood, and is a fairly good index of durability; (3) shortleaf heart-wood with a high percentage of summer wood is as resistant to decay as longleaf heart-wood with high percentages of summer wood, and *vice versa.*

Width of the rings of growth as an index of durability.—Since in specifications for structural timber the width of the annual rings has been closely associated with rules for grading, which involve density, chart VII was plotted to show the relation of the number of annual growth rings per inch to decay. The number of rings per inch measured on a radius of the stem are represented on the primary ordinate and on the primary abscissa the percentage loss in weight due to decay.

The results are very similar to those noted in chart VI; that is, we may conclude that (1) the width of the rings in the sap-wood of the three species of pine has little or no effect on the inroads of the fungus; (2) in a consideration of the

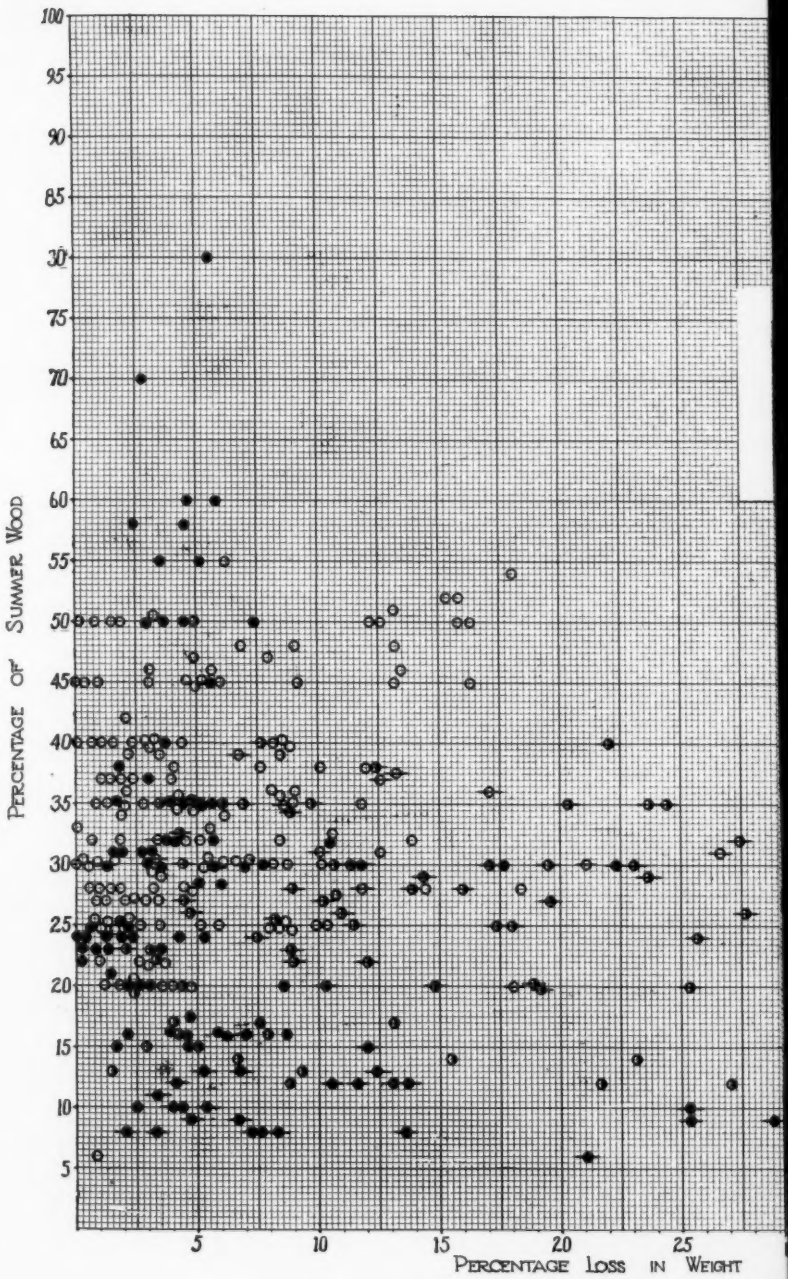


Chart VI. Showing the relation of pe

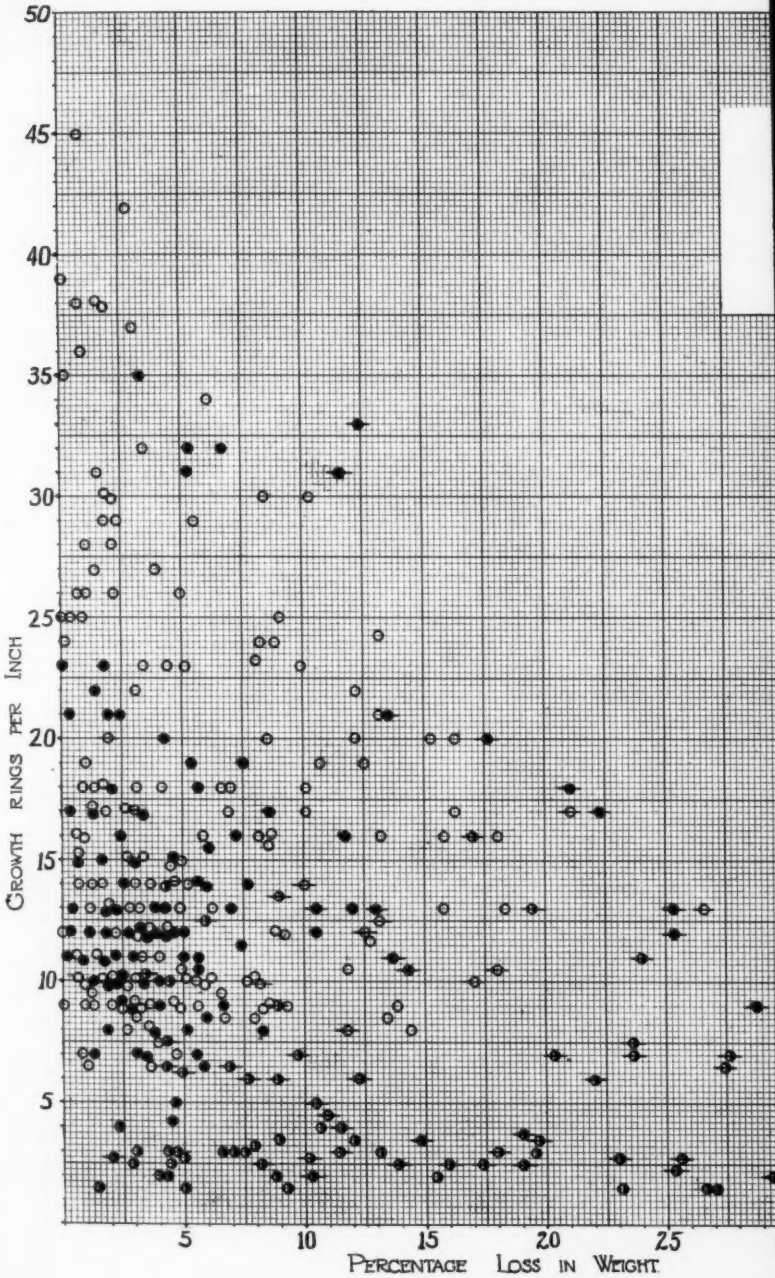


Chart VII. Showing the relation of numb

Chart VIII. Showing the relation of width

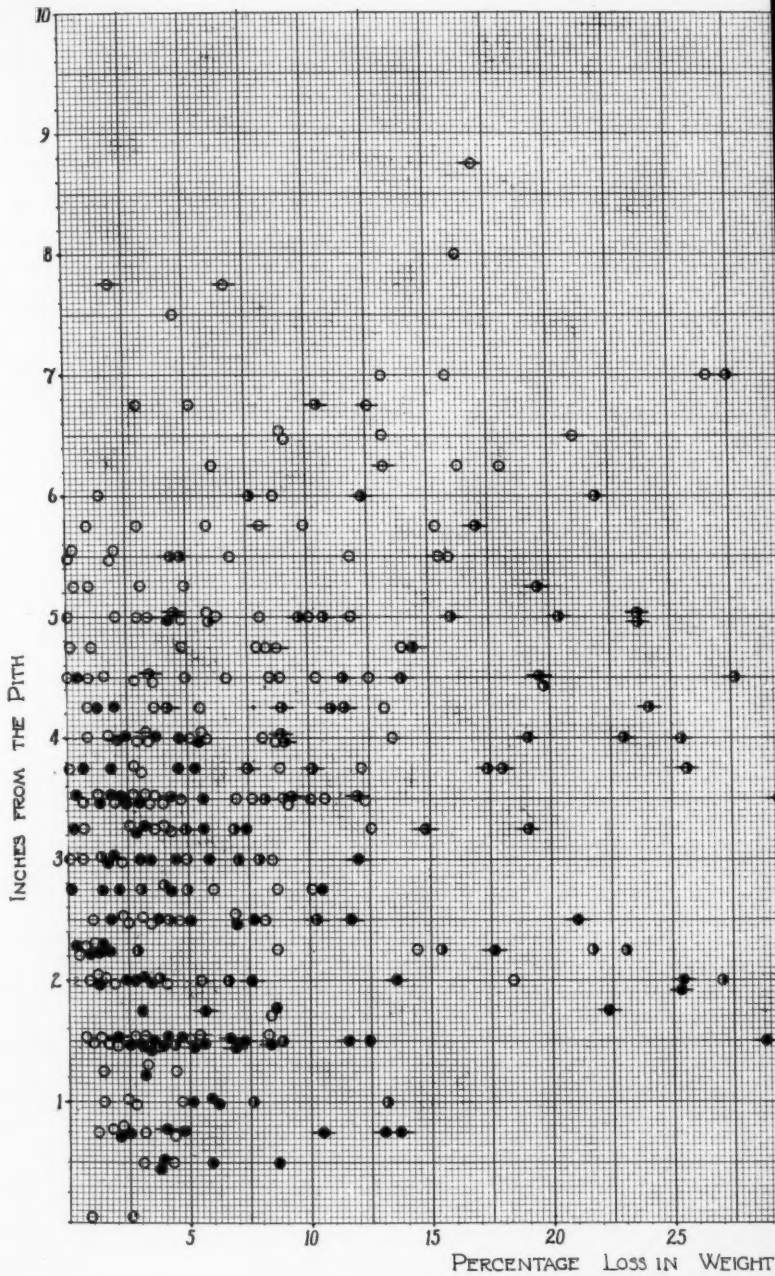


Chart IX. Showing the relation of the

heart-wood, the more resistant growth rings are the narrower ones, irrespective of species; (3) below a density of .75 the number of rings per inch must be closely associated with specific gravity, that is, by correlating the results here with those of chart IV, there is an indication that narrower rings indicate denser, more durable wood than open wide rings. This, however, could not be absolute, for the wide rings are often more than 75 per cent summer wood. In such cases they are resistant to fungous attack.

Chart VIII shows the relation of the number of growth rings per inch to density. With the exception of those blocks having a density over .75 due to high resin content the tendency in this chart is to show an increased density as the width of the rings decrease.

Distance from the pith as an index of durability.—Chart IX shows that distance from the pith, or age of the heart-wood, is no index of the durability of the heart-wood. Tests were made on pieces up to 16 inches in diameter. The sap-wood decays irrespective of distance from the pith.

SERIES B

See description of series B and table II above.

SERIES C

Chart X shows the relation of resin to the decay, induced by *L. saepiaria,* of yellow poplar blocks impregnated with resin. On the primary ordinate are represented the percentages of resin and on the primary abscissa the percentage loss in weight in one year. The plotted points are well scattered and show no definite course, unless there is a tendency to increase in percentage of decay with an increase of resin. When this is compared with chart XI, which shows the same relation for *Polystictus hirsutus,* there is an interesting contrast, for *Polystictus* seems to be inhibited, if anything, by resin. Although the points are well scattered, there is a tendency to show that *Lenzites* thrives more or less on benzol-soluble substances when infiltrated into the wood, while *Polystictus,* which usually grows on hard woods, does not.

Conclusions

It would seem that, from the results of the preliminary experiments discussed above, it would be safe to conclude that:

(1) Resin is no safe index of the durability of the three species of yellow pine investigated. Resin is not only undesirable for specifying durability because it is no safe index of decay resistance, but also because of the expenditure of time and labor necessary to make resin percentage determinations.

(2) On the other hand, specific gravity or density of the wood materially influences resistance to decay of the heart-wood, i. e., the more dense the wood the more durable it is, irrespective of the three species of wood examined.

(3) Specific gravity, however, is a property which can not be determined from inspection, but it can be estimated by recourse to the proportion of summer wood to spring wood in the growth rings, which proves to be a safe criterion of the durability of heart-wood; i. e., an increase in summer wood results in an increase in specific gravity.

(4) The width of the growth rings furnishes a further index of durability, the narrower rings showing more resistance to fungous attack than broad, open rings.

(5) The age, or distance from the pith of heart-wood, shows no relation to durability, at least up to 16 inches in diameter.

(6) Sap-wood decays irrespective of resin content, specific gravity, width of the annual rings, or species of pine.

(7) Shortleaf heart-wood or loblolly heart-wood is as durable as longleaf heart-wood, provided it has the same qualities as to specific gravity or density.

(8) Specifications for durability of the three species of pine considered should be based on a judicious combination of specific gravity, number of rings per inch, and the percentage of sap-wood. In other words, where pieces of the highest lasting powers are desired it will be necessary to specify pieces of the greatest density and with a minimum percentage of sap-wood. For inspection purposes the specific gravity may be estimated

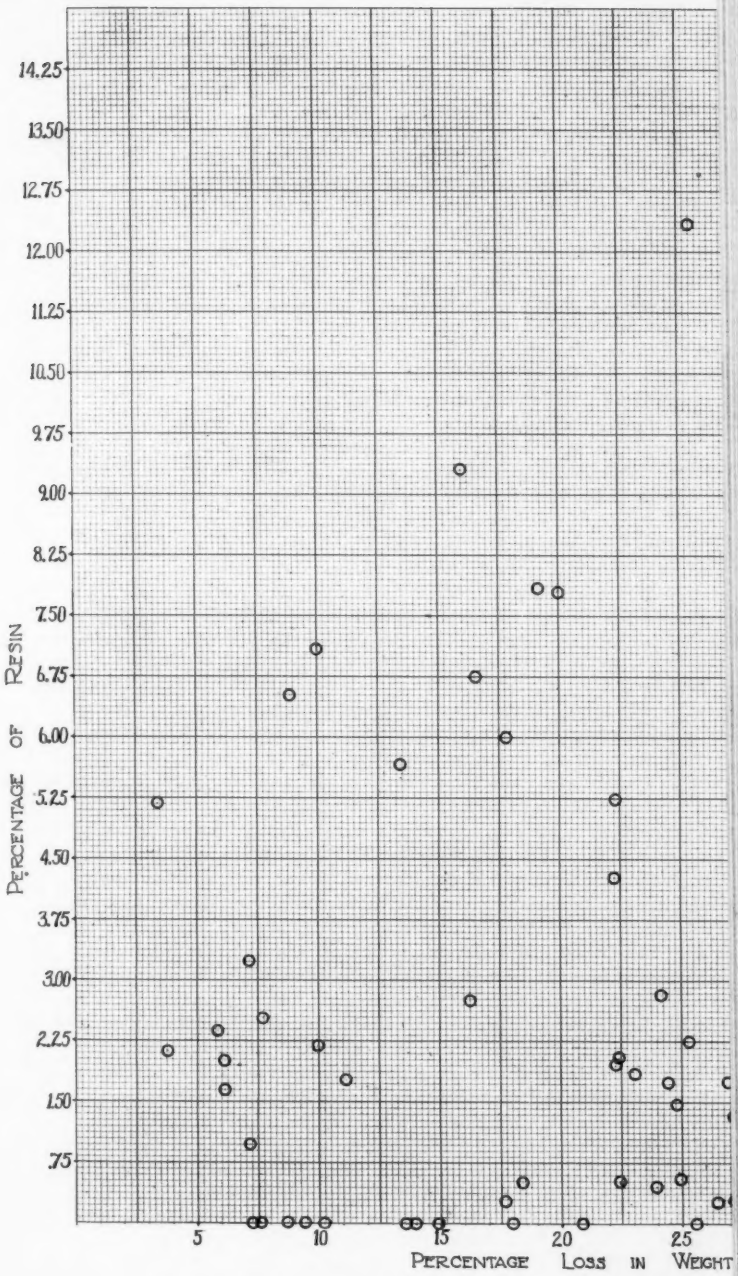
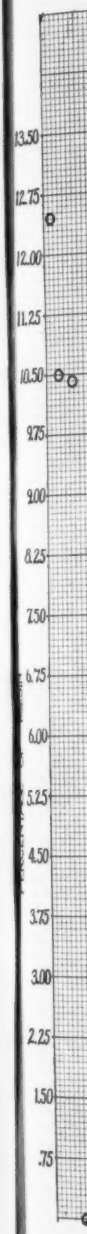


Chart X. Showing the influence of pine resin in impregnated yel


13.50
12.75
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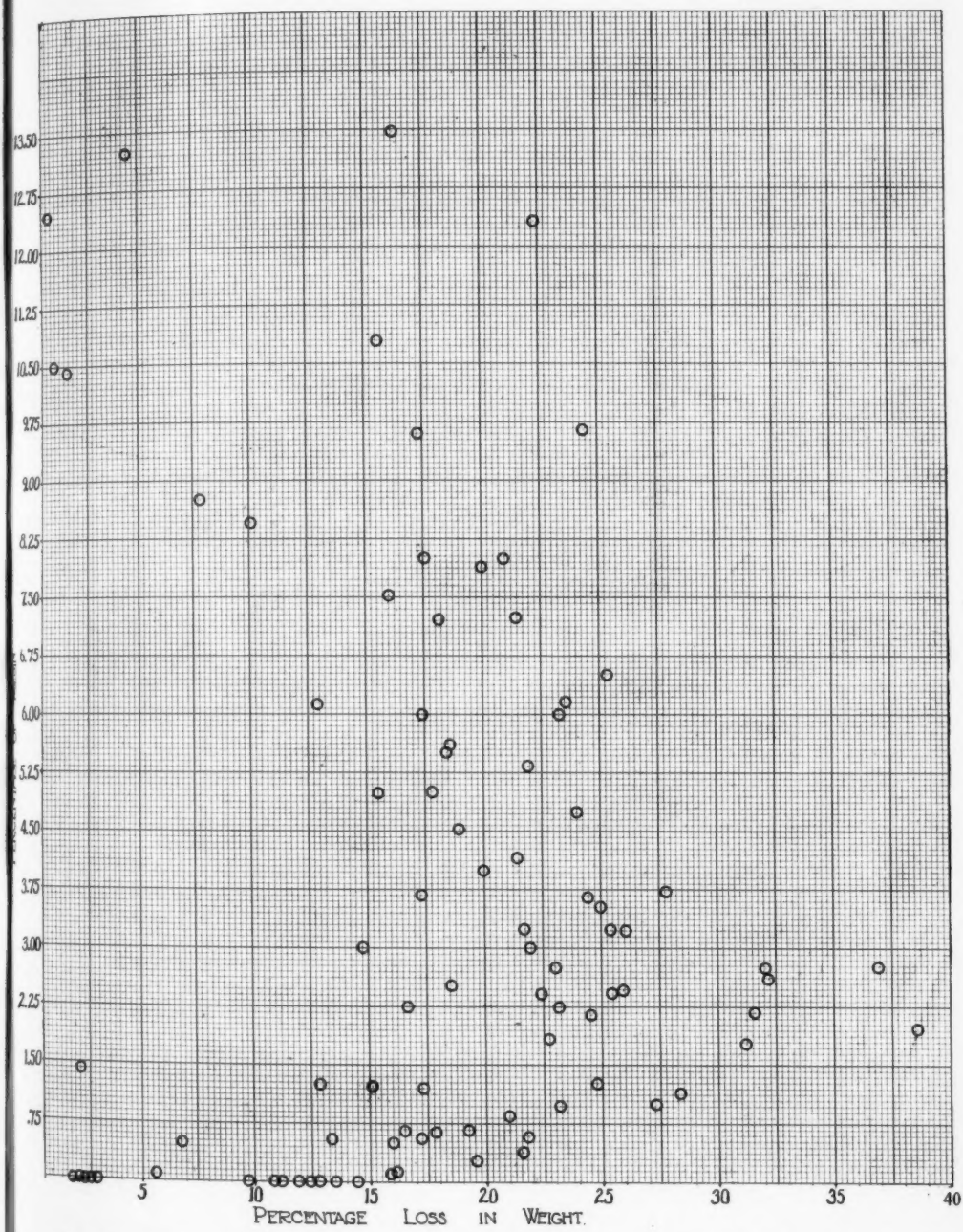

Chart XI. Showing the influence of pine resin in impregnated yellow poplar wood on its decay induced by *Polystictus hirsutus*.

by an examination of the percentage of summer wood. The more desirable pieces of timber are those containing broad bands of summer wood and narrow bands of spring wood as shown in the cross-section.

(9) The investigations thus far have been conducted to ascertain the toxic effect of resin on the fungous decay of wood. The results have shown that there are no toxic effects, but that there are other important relations of resin to decay, as, for instance, its waterproofing effect on wood and, thus, its influence on the absorption of moisture by wood containing it; that is, the power of wood to absorb moisture is very important in its decay. It is well known that below a certain minimum and above a certain maximum of moisture in wood *Lenzites saepiaria* and other similar fungi will not grow. Any property of the wood which will influence this balance of moisture is of importance in decay resistance. Thus, if the wood contains enough resin to have a material waterproofing effect it must play a rôle in durability. However, at present the percentage of resin necessary for such an influence is unknown. From the analyses given above it may be assumed that it is at least 5 per cent or more, but this would not be a safe basis for specifying decay resistance, since a piece of timber of low summer wood percentage (density) may contain this amount of resin, and yet be porous enough to be attacked by fungi. On the other hand, although not an absolute rule, it is generally true that a dense piece of heart-wood showing dark summer wood is more liable to contain at least 5 per cent resin than is a lighter piece. Hence, specifications based on high percentage of summer wood in most cases would more nearly fulfil requirements for durability than those based on resin content, at least until more is known concerning the influence of resin on the moisture-absorbing power of wood. The relation of resin to the absorbing power of pine timbers and the optimum relative humidity of the air for the decay of resin-containing wood are problems for further investigations. When this work is taken up again due consideration will be given to correcting the error due to sterilization. At a later time the probable error of the mean when dealing with

averages of the above data will be calculated and reported with the data taken from cultures incubated for a two-year period.

The sincere thanks of the writer are extended to the following, who have aided in various ways in this work: Dr. Hermann von Schrenk for suggesting the problem and for helpful suggestions in the work and in the preparation of the paper; the Southern Pine Association for financial aid; The Missouri Botanical Garden for the use of laboratories and library; Professor B. M. Duggar for helpful suggestions and criticisms throughout the work; and Mrs. E. Bardell Zeller for help in making the calculations and in preparing the tables.

Graduate Laboratory, Missouri Botanical Garden.

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EXPLANATION OF PLATE

PLATE 9

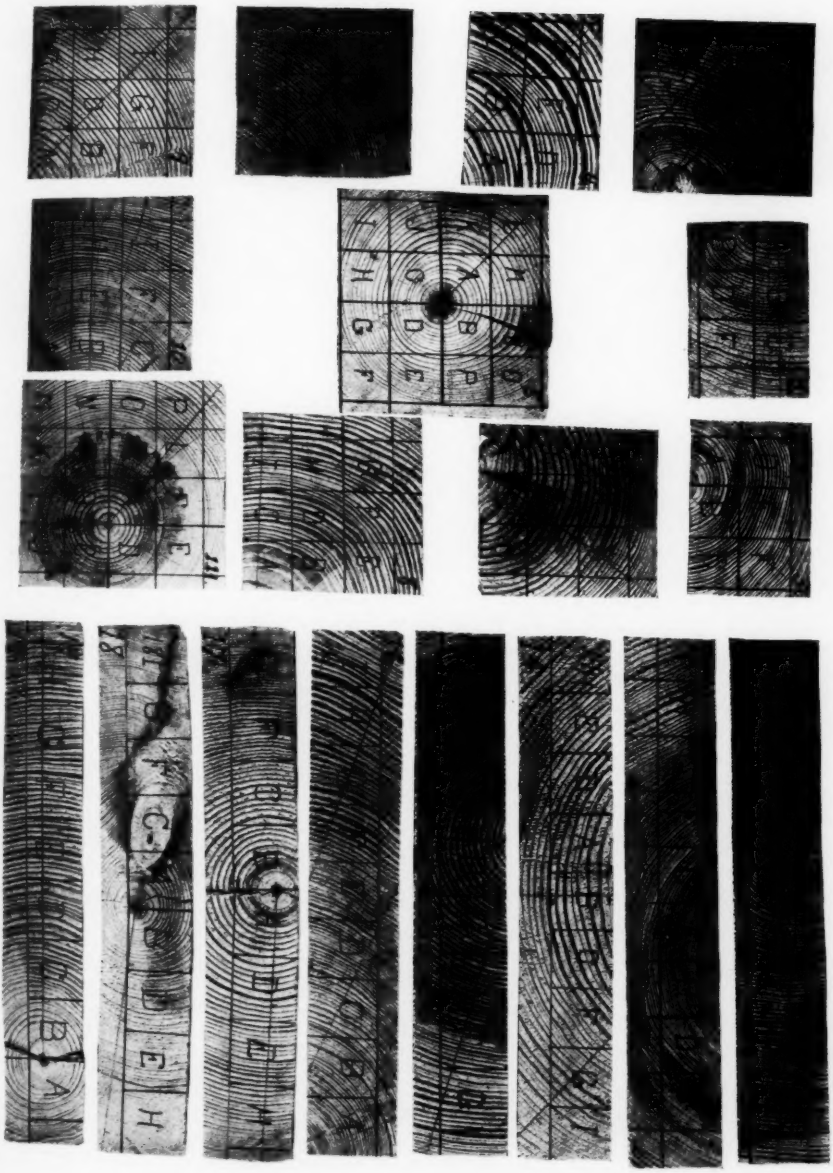
Showing the position of the blocks in culture, the method of plugging the jars for sterilization, etc.

ZELLER—DURABILITY OF YELLOW PINE

EXPLANATION OF PLATE

PLATE 10

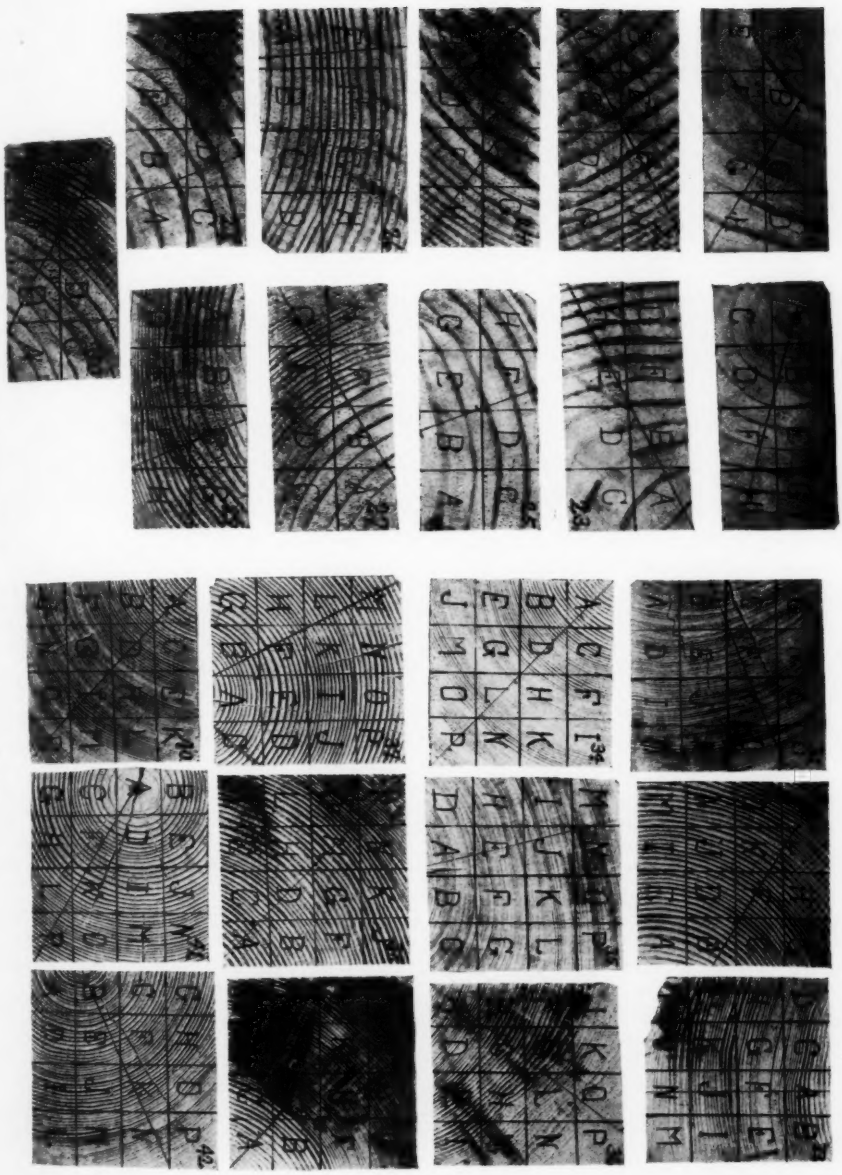
The original samples of pine (Nos. 1–19), marked off into squares one inch on a side and labeled with a letter representing the various columns of culture blocks given in table I. Numbers 1–11 are shortleaf pine (*Pinus echinata*) and Nos. 12–19 are longleaf pine (*P. palustris*).



EXPLANATION OF PLATE

PLATE 11

The original samples Nos. 20–42. Samples 20–30 are loblolly pine (*Pinus Taeda*) and 31–42 are longleaf pine (*P. palustris*).

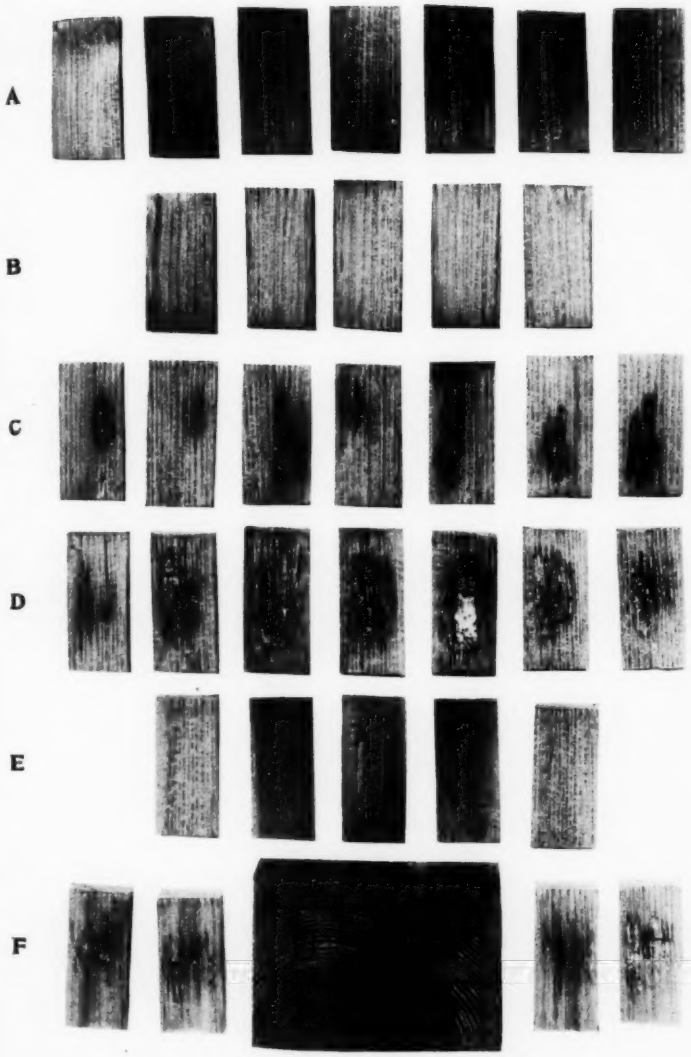


EXPLANATION OF PLATE

PLATE 12

The original sample No. 3 of shortleaf pine together with sections of the culture blocks, which were split after *Lenzites saepiaria* had grown upon them for one year. Samples from the columns A, B, C, D, E, and F are shown; columns A, B, and E are all, or nearly all, heart-wood, while C, D, and F are nearly all sap-wood. This shows graphically the decay of the sap-wood and the resistance of the heart-wood in comparison. The average specific gravity, average decay, and resin content of the columns are given here for reference.

Column	Resin percentage	Specific gravity	Decay percentage
A	4.8	.653	6.12
B	2.8	.665	2.12
C	3.3	.705	11.73
D	2.5	.658	22.30
E	3.2	.686	5.69
F	2.1	.624	17.68



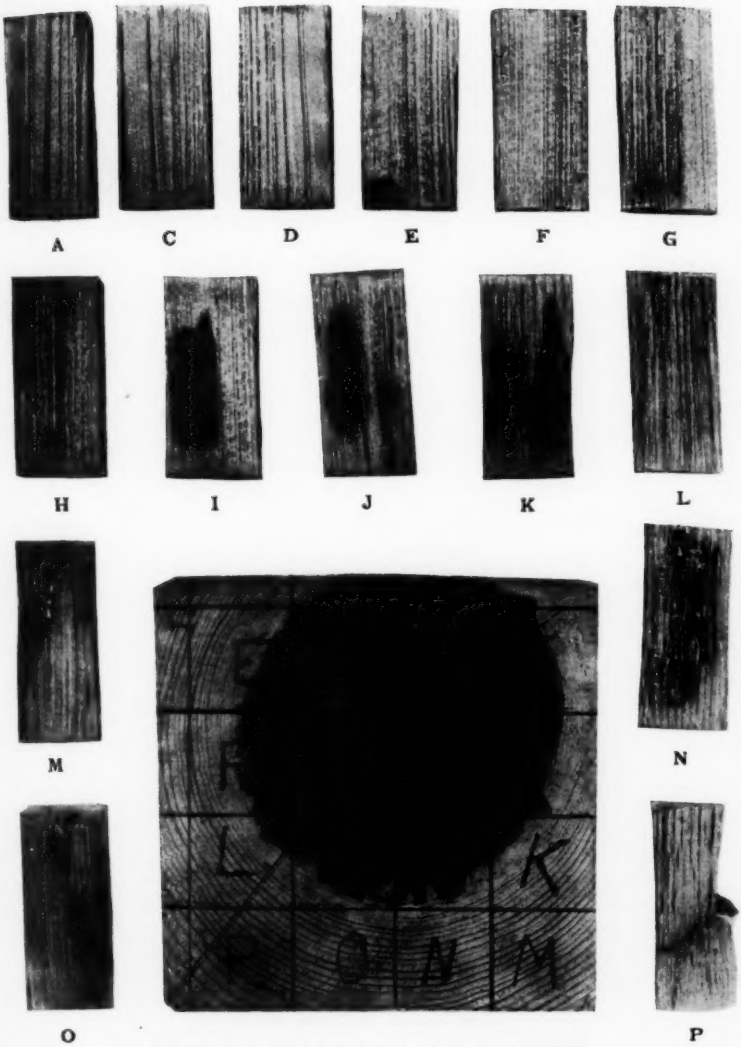
ZELLER—DURABILITY OF YELLOW PINE

EXPLANATION OF PLATE

PLATE 13

The original sample No. 11 of shortleaf pine together with split sections of the culture blocks chosen from the various columns as labeled. As in pl. 12, the resistance of the heart-wood to fungous decay is shown. The average specific gravity, average decay, and resin content of the various columns are given herewith:

Column	Resin percentage	Specific gravity	Decay percentage
A	22.98	.674	5.90
C	18.50	.646	3.84
D	21.04	.682	8.68
E	14.32	.526	5.36
F	10.64	.495	3.34
G	8.94	.539	6.75
H	25.34	.551	5.25
I	18.30	.469	11.60
J	13.38	.487	12.40
K	2.04	.428	31.80
L	1.36	.433	54.30
M	1.44	.426	57.10
N	1.26	.433	30.51
O	3.56	.453	21.10
P	3.24	.461	52.50



ZELLER—DURABILITY OF YELLOW PINE

STUDIES IN THE PHYSIOLOGY OF THE FUNGI

IV. The Growth of Certain Fungi in Plant Decoctions Preliminary Account

B. M. DUGGAR, J. W. SEVERY, and H. SCHMITZ

While undertaking an extensive study of the nutrition of *Aspergillus niger* in the so-called "synthetic" nutrient solutions it seemed well to determine the growth relations of this fungus and others in various plant decoctions, used either alone or in conjunction with one or more of the more important constituents of the usual synthetic nutrient solution. Numerous studies upon the growth relations of certain fungi with special reference to the sources of carbon and nitrogen have been made by various investigators, likewise considerable work has been done in the direction of determining favorable concentrations of mineral nutrients. Very few data of practical importance have come to the writers' attention bearing upon the nutrient value of the different plant decoctions often employed in culture work. The data here included are of preliminary nature, and merely in respect to a few plant decoctions, but they are sufficiently definite and suggestive to indicate that a complete study of the relations of a considerable number of parasitic and saprophytic fungi to such media would throw valuable light upon many problems which confront the physiologist and pathologist in respect to the artificial cultivation of such fungi. In the study here reported little consideration is given to the relation between vegetation and spore formation, but it is our intention to discuss this point at length in a later report.

Realizing the necessity of adopting some standard in the preparation of plant decoctions it has been the custom in all quantitative work in this laboratory to calculate the amount of the raw vegetable product to be used on the basis of dry weight. The standard employed[1] has been 50 grams dry weight of the product per liter of water, and this has been found to be a satisfactory quantity for most materials. Plant mate-

[1] Duggar, B. M. Fungous diseases of plants. p. 24. 1909.

rials vary so greatly in water content that if any satisfactory standard is adopted it is necessarily on the dry weight basis. Accordingly, for the plant products utilized in preparing the decoctions employed in this work, the quantities required, as calculated from the data in convenient handbooks,[1] are as follows: green (string) beans 391.5 grams; corn meal 58.6 grams; fresh turnips 524.1 grams; sugar beets 370.4 grams; prunes (dried, exclusive of seed) 70.7; and potatoes 236.8.

It is obvious that such plant products will vary more or less in water content depending upon the variety and the season, but this is relatively a minor consideration.

In each case the full weight of material required was cut up into small pieces (not more than 1 cm. in length or diameter), added to 1 liter of water, autoclaved at 15 pounds pressure for 1 hour, filtered hot, and made up to the full quantity, if there had been loss of water. It was determined to use the natural (or native) decoction in each case, and also each one amended as indicated in the series below, these also corresponding to the 7 columns (I–VII) of nutrient media in table 1.

I Natural decoction, full strength.

II Natural decoction, full strength standardized in reaction to + 15 Fuller's scale.

III One-half strength standardized decoction + 13.68% (.4N) cane sugar.

IV One-half strength standardized decoction + 3.42% (.1N) cane sugar.

V One-half strength standardized decoction + 13.68% cane sugar + 1% KNO_3 + .5% KH_2PO_4.

VI One-half strength standardized decoction + 13.68% cane sugar + 1% KNO_3.

VII One-half strength standardized decoction + 13.68% cane sugar + .5% KH_2PO_4.

A part of each decoction was therefore set aside to be used in natural condition while the remainder was titrated,

[1] Jenkins, E. H., and Winton, A. L. A compilation of analyses of American feeding stuffs. U. S. Dept. Agr., Exp. Sta. Bul. 11. 1892.

König, J. Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel. Berlin, 1889.

using phenolphthalein as an indicator, and brought to approximately + 15 Fuller's scale,—standard HCl or NaOH being used to obtain the desired reaction.

The reactions of the various natural decoctions on the Fuller scale were as follows: bean + 15, corn meal + 3, turnip + 11.5, sugar beet + 22.6, prune + 14.5, and potato + 11.5. The bean and prune decoctions were left in the "natural" condition, so that the duplicate cultures representing columns I and II for these decoctions were equivalent, and in table 1 the dry weight data are repeated merely for the completion of the table. Immediately after the addition of the required acid or alkali to the other decoctions, a second titration was carried out and a further correction made. Special attention should be drawn to the fact that in I and II full strength decoctions were employed, while in III–VII the decoctions were one-half strength. In later series, not reported upon here, dilution of the decoctions has been avoided, or half strength "control" decoctions also employed.

The cultures were made in duplicate in small Erlenmeyer flasks (125 cc. capacity), each containing 25 cc. of solution. The flasks were sterilized at 15 pounds pressure for 20 minutes.

It seemed desirable to employ fungi with somewhat different habits of growth, including at least one parasitic species, and the following species were chosen, namely, *Macrosporium commune, Aspergillus niger, Glomerella* (*Gloeosporium*) *Gossypii,* and *Penicillium expansum.* Spores were taken from fresh cultures grown 7–10 days on potato agar, except in the case of *Glomerella,* which was grown on bean agar. Under aseptic conditions a strong spore suspension for each organism was made in sterile distilled water, and 4 drops of a suspension were added to each flask in the series for that organism. All cultural operations were executed in a transfer room in which all dust was thoroughly precipitated by steam. No contaminations resulted in any of the 256 cultures made. All the cultures were set up and taken down within one week of each other, while those with any one organism were arranged at the same time and held

at the same temperature for the same interval. The following indicates this:

	Inoculated	Discontinued	No. of days
Macrosporium commune	February 8	February 22	14
Aspergillus niger	February 7	February 21	14
Glomerella Gossypii	February 3	February 20	17
Penicillium expansum	February 7	February 24	17

For all species the temperature variation during the interval of incubation was 20–22° C.

TABLE I

DRY WEIGHTS OF CULTURES ON PLANT DECOCTIONS

Fungus	Weight in grams							
	I	II	III	IV	V	VI	VII	
	Natural decoction	Standardized decoction	½ strength standardized decoction + 13.68% cane sugar	½ strength standardized decoction + 3.42% cane sugar	½ strength standardized decoction + 13.68% sugar + 1% KNO_3 + .5% KH_2PO_4	½ strength standardized decoction + 13.68% sugar + 1% KNO_3	½ strength standardized decoction + 13.68% sugar + .5% KH_2PO_4	Decoction
Macrosporium commune	.119	.119	.562	.295	.....	.....	.....	Bean
Aspergillus niger	.092	.092	.239	.183	.796	.653	.219	
Glomerella Gossypii	.058	.058	.275	.300	.337	.290	.280	
Penicillium expansum	.070	.070	.214	.127	.....	.....	.....	
Macrosporium commune	.068	.018	.059	.060	.....	.....	.....	Corn meal
Aspergillus niger	.055	.086	.116	.085	.492	.171	.144	
Glomerella Gossypii	.069	.025	.094	.052	.139	.101	.096	
Penicillium expansum	.069	.026	.100	.041	.....	.....	.....	
Macrosporium commune	.131	.135	.563	.231	.....	.....	.....	Turnip
Aspergillus niger	.078	.083	.152	.101	.569	.412	.146	
Glomerella Gossypii	.074	.074	.245	.213	.317	.291	.167	
Penicillium expansum	.079	.077	.125	.091	.....	.....	.....	
Macrosporium commune	.370	.257	.493	.275	.....	.....	.....	Sugar beet
Aspergillus niger	.239	.183	.275	.182	.921	.467	.302	
Glomerella Gossypii	.271	.225	.521	.369	.478	.268	.396	
Penicillium expansum	.190	.139	.195	.137	.....	.....	.....	
Macrosporium commune	.111	.111	.628	.285	.....	.....	.....	Prune
Aspergillus niger	.073	.073	.133	.100	.563	.448	.188	
Glomerella Gossypii	.087	.087	.139	.116	.203	.142	.146	
Penicillium expansum	.046	.046	.128	.053	.....	.....	.....	
Macrosporium commune	.088	.088	.661	.308	.....	.....	.....	Potato
Aspergillus niger	.069	.118	.212	.139	.832	.717	.197	
Glomerella Gossypii	.101	.091	.216	.225	.368	.239	.185	
Penicillium expansum	.057	.055	.205	.126	.....	.....	.....	

Growth was satisfactory on all media except the corn meal decoction, yet the amount of growth was considerably less

than anticipated on several of the other media. In further work extensive comparisons will be made between the value of decoctions and some other standard nutrient solutions. On corn meal decoction the growth was particularly unsatisfactory and irregular with *Glomerella* and *Macrosporium*. Moreover, there was gradually deposited in all solutions of this decoction (more in the standardized solutions) a considerable flaky precipitate, and this interfered seriously with correct weight determinations of the mycelium formed, as may be inferred from an examination of table 1.

Filter papers 9 cm. in diameter were dried to constant

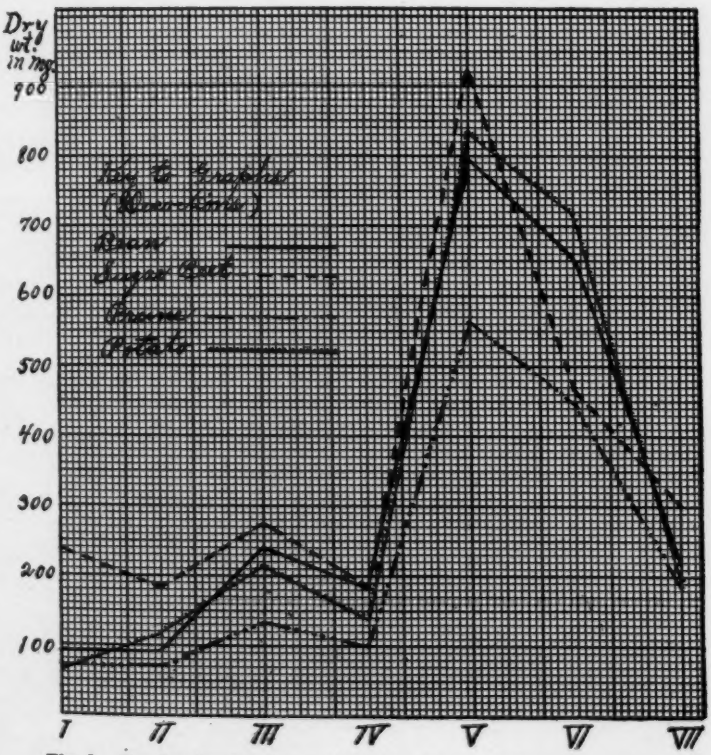


Fig. 1. Graphs showing dry weights of cultures of *Aspergillus niger;* dry weights of felt plotted on ordinates, the solutions (see p. 166 for explanation) on abscissae.

weight at about 105° C., then transferred directly to desiccators with anhydrous and freshly oven-dried $CaCl_2$. After 24 hours they were accurately weighed to the third place and marked with weight and number. As a result of the apparent variations in growth it was determined to make hydrogen ion determinations of the solutions, so that under aseptic conditions the remaining culture fluid was poured off into test-tubes for later use, the mycelial mat being then thrown on to the filter, as also flask washings. The filters were then again dried to constant weight at about 105° C., and placed in desiccators until carefully weighed.

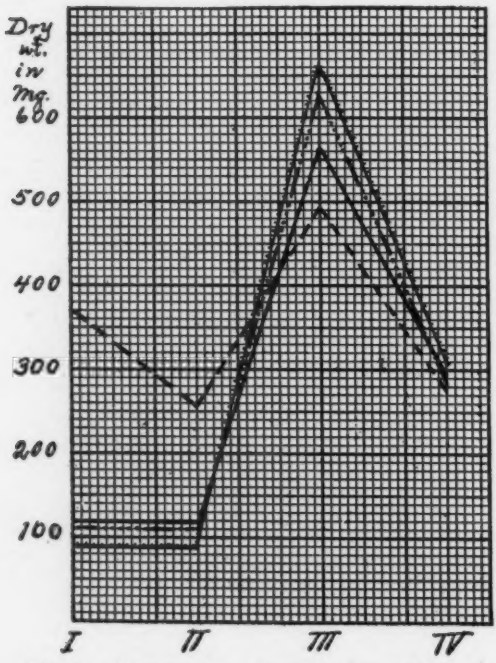


Fig. 2. *Macrosporium commune;* dry weights of cultures in mg. on ordinates, solutions (see p. 166 for explanation) on abscissae. Key to graphs in fig. 1.

In table 1 the average weights of the felts from the duplicate series are given. The results in the duplicate series with all decoctions except corn meal were sufficiently consistent. As mentioned above, in the case of corn meal it was impossible completely to separate the precipitate from the slight mycelial growth, so that the figures in the table are somewhat too large, and, as between duplicate members, there were weight differences not borne out by the record of observations.

The more important data are likewise strikingly shown in

the curves exhibited in figs. 1–4, these representing all four organisms on four of the decoctions, namely, bean, sugar beet, prune, and potato, the data for turnip decoction being omitted merely (a) because it follows very closely in three of the fungi

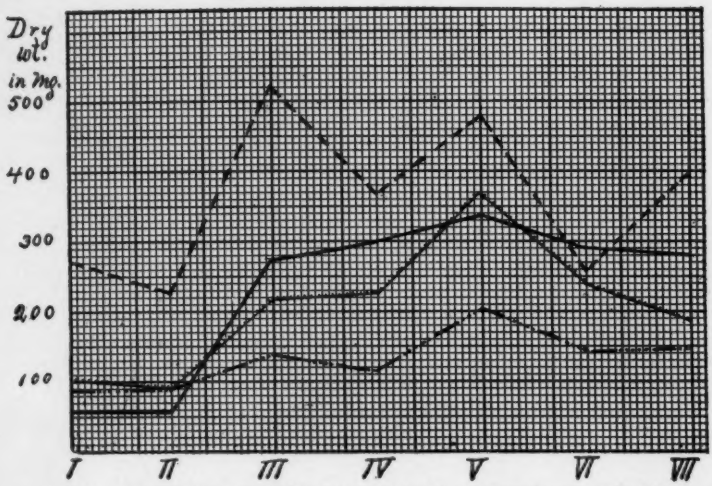


Fig. 3. *Glomerella Gossypii;* dry weights of cultures in mg. on ordinates, solutions (see p. 166 for explanation) on abscissae. Key to graphs in fig. 1.

the curves of the prune decoction, (b) because it would further have complicated the diagrams, and (c) because on the whole it is much less used as a culture medium.

Some of the interesting features of the curves in general are these:

The addition of sugar, nitrate, and phosphate gives in every case except one (*Glomerella* on bean decoction) increase in growth over the addition of sugar alone. In the majority of cases the next highest growth occurs when sugar and nitrate are added. The addition of sugar alone gives a relatively slight increase over the natural decoction, although it is to be remembered that where sugar or other nutrients are added the decoction is diluted one-half. In *Aspergillus* the addition of sugar and phosphate gives a slight increase over the addition of the same concentration of sugar alone. In

the case of *Glomerella* this is variable with the different decoctions. An attempt to standardize the sugar beet decoctions has resulted with every fungus in a slight decrease of growth in comparison with that in the natural decoction. On the whole, the prune decoction has yielded less growth than either of the other three plotted in the curves except in the case of one organism, *Macrosporium*.

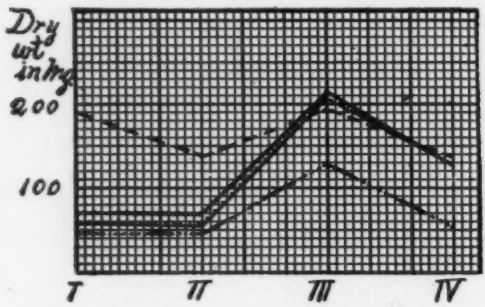


Fig. 4. *Penicillium expansum*; dry weights of cultures in mg. on ordinates, solutions (see p. 166 for explanation) on abscissae. Key to graphs in fig. 1.

Unfortunately, hydrogen ion determinations were not made at the time the cultures were installed, so that in order to obtain results for the original solutions it was necessary to prepare a second lot of the decoctions. These would undoubtedly correspond very closely to those employed for the cultures, and are therefore fairly suitable controls for changes in hydrogen ion concentrations occurring during the growth of the organisms. In this work the colorimetric method was employed, and it is unnecessary here to give the details of the method further than to say that the standard solutions of Sörensen, as modified by Henderson, as well as all available indicators of merit were used.

With reference to the hydrogen ion concentration of the control or original solutions, it is to be noted that little difference was found between the natural decoctions of bean, turnip, prune, and potato, that is, after standardization,—all of these being approximately 10^{-4}. These decoctions, moreover, were only influenced to a slight degree by the addition of sugar or nutrient salts as previously described. After standardization the sugar beet decoction was about 10^{-3} and the corn meal 10^{-2}. It was evident, therefore, that the attempted standardization of corn meal to + 15 Fuller's scale actually

left the solution differing widely from the majority of the decoctions in hydrogen ion concentration.

The changes which were induced in the hydrogen ion concentration in the various solutions as a result of the growth of the different fungi is worthy of mention. In all solutions except the sugar beet and the corn meal decoctions, *Aspergillus* caused, as might be expected, a shift toward the acid side, usually to about 10^{-3}, while *Macrosporium* and *Glomerella* generally induced a pronounced shift in the other direction, these last, however, varying from a scarcely perceptible change in prune decoction to a maximum in the turnip, bean, and potato decoctions, where the test indicated from 10^{-6} to 10^{-8}. In the cultures of *Penicillium* acidity was evidently developed in the bean, turnip, prune, and potato decoction whenever sugar was added, but alkalinity was developed in the natural and standardized decoctions.

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STUDIES IN THE MOSAIC DISEASES OF PLANTS

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The particular group of diseases commonly known as "physiological" diseases has occupied the attention of botanists — pathologists and physiologists — for the last forty years, but it is doubtful whether the interest has ever been as keen as that which has been evidenced through the investigations and reports of the last few years.

Probably the commonest of the physiological diseases and the most studied, at least from the standpoint of the number of scientists whose attention it has occupied, is the one most generally known as the mosaic disease. The discovery of the disease, its appearance, and the results of the early investigators have been adequately reviewed in recent publications, while its occurrence on new hosts has furnished the subject matter of a number of short articles which have appeared recently. The object of this paper is primarily that of reporting the results obtained from experiments on mosaic diseases, but an attempt will also be made to review the observations and results of the early workers, with a view of interpreting them in the light of the results of recent investigations, and above all, to consider all evidence now known on the basis of the fundamental principles of physiology and pathology with the hope of arriving at a clearer conception of the cause and nature of mosaic diseases.

The most striking character is the differentiation of the green tissue of the blade into lighter diseased and darker apparently healthy areas. This naturally implies a difference in the chemical composition of the tissue and suggested a microchemical study of the differentiated areas of the diseased leaves. It was hoped that the chemical differences exhibited between sharply defined areas might furnish a clue to the cause of the anatomical and histological differentiations.

MICROCHEMICAL TESTS

In attempting the solution of a pathological problem by microchemical methods one must bear in mind that even individual healthy plants may, under apparently normal conditions, vary in their chemical composition. Differences in environmental factors, though relatively imperceptible, may be sufficient to change, for example, the acidity of plant tissues, while the more obvious effect of shade or decrease of illumination is evidenced in a decreased accumulation of fats, carbohydrates, and proteins. For this reason it is important that comparative analyses be made, not only on the same plant but on the same leaf and on adjacent areas. The microchemical methods now available are the results of investigations on normal healthy tissues, and some may think that their application to pathological tissues is unwarranted, and that the results obtained should therefore be interpreted with considerable reserve until the general application of the tests has been more definitely established. Microchemical tests, especially those outlined in the works of Molisch ('13) and Tunmann ('13), have arisen from innumerable tests on plants distributed throughout the vegetable kingdom. If their position is justified in the study of healthy tissue, they may well find a place in pathology.

The results obtained from a microchemical study should, whenever possible, be verified by macrochemical analyses or by other appropriate methods, as we are able to do for nitrogen by means of the Folin micro-Kjeldahl method. Considerable difficulty, however, will be experienced in getting enough material from well-differentiated areas of any one leaf or part of a leaf to make macrochemical analyses, and since no delicate macrochemical methods for the general analysis of plant tissues other than for nitrogen are available, the microchemical results reported below will have to suffice for the present. The results, furthermore, are not only relative as regards the comparison between different tissues, but are relative in themselves, since no absolute value can be determined and one is obliged to rely entirely upon impartial

judgment and the uniformity of results obtained from an extensive number of tests.

On account of the delicacy of the tests employed, all glassware and instruments used were cleaned with the greatest care. Even the pith used in sectioning the tissue was soaked and rinsed in alcohol and distilled water, and the sections were rinsed before the application of reagents, in order to insure the removal of all superficial and extraneous salts or foreign matter. The best reagents obtainable were used throughout the work. The results obtained with diseased tissue were always contrasted with those obtained with healthy tissue. The texts of Molisch ('13) and Tunmann ('13) not only served as an outline for the methods employed, but also as an index to the extensive literature on microchemical reactions.

NITROGEN

The detection of inorganic nitrogen in plants was first attempted in the work by Molisch ('83), and it is to these researches that all subsequent work owes its foundation. The test for nitrogen is based upon the fact that nitrates and nitrites give a blue color with diphenylamine, while a red color results upon the application of brucine.

Reaction with diphenylamine.—The most reliable of all tests for inorganic nitrogen is the one based on the reaction of nitrogen with diphenylamine. The reagent is applied in the form of .01–.1 gram of diphenylamine in 10 cc. reagent sulphuric acid. Since diphenylamine is insoluble, or only very slightly soluble, in water, it is necessary to apply the reagent to dry sections. When applied to wet sections, the diphenylamine will be precipitated and thus be unable to react with the nitrogenous compounds. Sections are therefore placed on the slide and allowed to dry, after which enough of the reagent is applied adequately to cover the mount. In the presence of nitrates a blue color results which gradually fades, but almost invariably shades into a light brown. The test may be negative or the reaction almost imperceptible in the presence of very minute quantities of nitrogen. In this

event, the reaction may be intensified by using thicker sections and a more concentrated solution of the reagent.

This reaction does not enable us to distinguish between nitrites and nitrates, but the former group of compounds has never been demonstrated in normal green tissues (Klein, '13) except in one plant, namely, *Erythrina coralloides* (Weehuizen, '09). The test employed by Weehuizen was as follows: The freshly expressed juice was tested with potassium iodide starch-paper. In the presence of nitrites a blue color developed which did not disappear upon treatment with sulphanilic acid and dilute sulphuric acid, but did turn to a carmine red upon the application of an alcoholic solution of alpha-naphthylamine. In adapting the test to the microchemical work, the potassium iodide starch-paper was made by soaking filter paper in a mixture of 50 cc. of ¼ per cent starch paste and 50 cc. of 3 per cent potassium iodide solution. A 0.1 per cent solution of alpha-naphthylamine was employed. Negative results were obtained when this test was applied to the juice expressed from diseased tobacco leaves.

Reaction with brucine.—Another test for inorganic nitrogen, though less delicate than that of diphenylamine, is the one with brucine. The reagent is applied as 0.2 gram brucine in 10 cc. reagent sulphuric acid. In the presence of nitrogen a deep red color is produced. In the presence of small quantities of nitrogen this test may fail completely, though results may have been obtained with diphenylamine.

When applying these tests to diseased tobacco tissue, fairly uniform results were obtained with diphenylamine. With brucine, however, the results were less satisfactory, being entirely negative or comparatively faint. This was true regardless of the kind of tissue examined, whether from the darker or the lighter areas. The results with diphenylamine, however, led the writer to conclude that not only is nitrogen present in both the lighter and darker areas, but that it is present in about the same quantity in both types of tissue.

AMMONIA

The presence of ammonia may best be determined by liberating the free gas by means of strong alkali, and collecting it with platinic chloride or Nessler's reagent. This can best be accomplished by placing a glass ring, the ends of which are smoothly ground, on a glass slide and placing in the center of the reservoir thus formed a drop of strong alkali. A drop of concentrated sodium hydroxide was used in the work reported here, and a narrow glass ring used for making hanging-drop cultures served to form the little compartment. The tissue to be tested was placed in the bottom of the compartment and enough sodium hydroxide was added adequately to cover the mount. After the addition of the alkali the compartment was covered immediately with a cover glass, to the lower surface of which there adhered a drop of platinic chloride or a drop of Nessler's reagent.

When Nessler's reagent was used, the drop assumed a deep yellow color which intensified, eventually resulting in the formation of a brown precipitate. In the case of platinic chloride, characteristic octahedral crystals of ammonium platinic chloride separated out. The detection of ammonia in plant tissue has been attempted on the part of various workers by applying Nessler's reagent directly to the sections. This test is, according to Molisch, unreliable, since various constituents of the tissue may not only change the color of the reagent to a yellow or brown, but a yellow color may be developed when alkali alone is applied to the tissue. Volatilization of the ammonia in the manner described is therefore the only reliable method for its detection.

When these tests were applied to the diseased leaves, splendid results of equal intensity were obtained regardless of the kind of tissue used. It was therefore concluded that salts of ammonia might, as a source of nutrition, serve all cells to the same degree.

TOTAL NITROGEN

An unbalanced nitrogen relation between diseased and healthy tissues has been cited as a partial explanation of the cause of mosaic diseases (Woods, '02). It therefore became

desirable to know whether the chlorotic area differed markedly in its nitrogen content from that of the adjacent green, and apparently healthy, tissue. In this work some of the older leaves had to be used, since the younger leaves, because of the limited amount of differentiated tissue, did not enable one to obtain enough material from adjacent areas to carry on the tests.

The Folin micro-Kjeldahl method was employed in this work. The results, however, especially for total nitrogen, were somewhat inconsistent, and the analyses can only be regarded as preliminary. The tests, nevertheless, showed no marked difference between the nitrogen content of diseased and healthy tissue. In fact, the nitrogen content of the lighter areas seemed to be slightly in excess of that of the darker areas. More extensive analyses are in progress at present, the results of which will be reported at a later date.

PROTEINS

The interesting results obtained from the nitrogen analyses suggested their possible correlation with the protein content of the differentiated areas. The limited amount of material made the extraction of protein impossible and microchemical tests were therefore resorted to. The tests commonly used in biochemical work were applied to both macerated tissue and hand-cut sections. Those used with advantage were the following:

1. Millon's test: Millon's reagent was applied to the material and the slide warmed gently over a micro-burner. A brick-red color developed, signifying the presence of protein. Millon's reagent consists of mercury dissolved in nitric acid (sp. gr. 1.42) in the proportion of 1:2 by weight. When the action of the acid on the mercury has ceased, the solution is diluted with water to twice its volume.

2. Biuret test: The material to be tested was placed on the slide and treated for about 15 minutes with a few drops of strong sodium hydroxide. The alkali was then allowed to drain off, and the material was rinsed with water and treated with a trace of 5 per cent copper sulphate. After several

minutes a violet color developed, indicating the presence of protein. This test is a comparatively difficult one.

3. Xanthoproteic reaction: Strong nitric acid was applied to the material and the slide warmed gently over a microburner. A yellow color developed which changed to orange upon the application of strong ammonia.

4. Iodine test: With iodine a deep yellow to brown color developed.

In all of these tests a more pronounced reaction was obtained with the lighter or diseased areas than with the darker. In the former the color showed up somewhat faster and was more intense. We may not be justified, however, in assuming that there is actually a great deal more protein in the chlorotic area than in the other, since the values in all of this work are only relative in themselves, and the excess of carbohydrates, etc. present in the deep green areas may obscure the above reactions in part. We would, however, be safe in stating that there is as much protein in the lighter areas as in the darker, and that there is a probability of there being more in the former than in the latter. The validity of this statement can only be determined by accurate quantitative methods.

It was originally intended to make analyses for amino nitrogen by the Van Slyke ('13) method, but because of the need of choice material for other work reported here, this determination had to be deferred.

IRON

Iron is one of the elements absolutely indispensable for plants, and may be present in the tissue in either organic or inorganic combination. Since it is universally conceded that a lack of iron is directly responsible for a certain type of chlorosis or the inability of the plant to form chlorophyll, it was desired to show, if possible, whether there was any marked difference between the iron content of lighter and darker areas of diseased leaves. In making these tests, iron-free chemicals, glass needles, and a new highly polished razor were used, thus obviating all possible sources of error.

Tests were made for ferric iron by treating the section on the slide for an hour or more with a 2 per cent solution of potassium ferrocyanide and then adding a 5 per cent solution of hydrochloric acid. In the presence of comparatively large amounts of iron, a deep blue (Berlin blue) color results. When only traces or minute quantities of iron are present, the reaction may be negative or a blue-green tinge developed. In this event it may be confused with the natural pigments and the results must be checked by more reliable methods.

Fairly uniform results were obtained with the method described, but further evidence was secured in the following manner: The surfaces of well-mottled leaves were washed and rinsed with distilled water, thus removing all foreign matter, and the well-defined areas cut out by means of a sharp glass needle. These were then dried in an oven. Lacking a platinum plate, the samples were ignited on a glass plate and the above reagents applied. A marked reaction resulted. This method, furthermore, possessed the desirable feature that no metal instruments were used in handling the material. No serious error, however, should have been introduced by cutting the sections with a highly polished razor.

The following test has been described for the detection of ferrous iron: The material is treated with a 2 per cent solution of potassium ferrocyanide or potassium cyanide for an hour or more. A few drops of 5 per cent hydrochloric acid are then added. In the presence of ferrous iron a blue color (Turnbull blue) results. This test proved negative in both diseased and healthy tissue.

When iron is present in organic combination it may be detected by incubating the material at about 60° C. with a solution of ammonium sulphydrate and 50 per cent glycerin mixed in aliquot proportions. The sections were placed on the slide, the reagent applied, and covered with a cover glass. Upon the liberation of the combined iron, varying from a few days to a few weeks, a very dark green or almost black color signified the presence of ferrous sulphide. Uniform results were not obtained with this method, but this might be attributed to the fact that the amount of iron present in the

small section was not sufficient to give a noticeable reaction.

From the tests on ferric iron it would appear that there is sufficient of this element present in all tissue to warrant the normal development of all cells.

CALCIUM

Calcium is generally detected as calcium sulphate. The sections were treated with a 3 per cent solution of sulphuric acid and allowed to stand until most of the solution had evaporated. Small plate-like crystals or needles of calcium sulphate were then noticeable in the remaining reagent, especially along the edges of the sections and in the intercellular air-spaces.

A second test applied was that with ammonium oxalate. The sections were treated with a 5 per cent solution of ammonium oxalate in a 10 per cent solution of acetic acid. The precipitate of calcium oxalate assumed the form of very small granules. The sections were tested further by adding a 5 per cent solution of oxalic acid containing a small amount of acetic acid. This gave satisfactory results, precipitating the calcium as minute crystals of calcium oxalate, pyramidal in form. The test was applied with equal success to all tissue.

MAGNESIUM

Besides being an indispensable element in the general nutrition of the plant, magnesium is important as an antidote for calcium and as a constituent of chlorophyll. Tests for magnesium were made by treating the sections with a 0.1 per cent solution of $NaH(NH_4)PO_4$ and placing the slide in a moist chamber containing a vessel filled with strong ammonia. The ammonia vapor killed the tissue and rendered the cell easily permeable to the sodium ammonium phosphate. After several minutes, crystals of magnesium ammonium phosphate separated out. These were either short and triangular in form, or, depending upon the quantity of magnesium present and also upon the time for which the reagent was allowed to react, were x-shaped or stellate in form, the appendages assuming a feather-like structure.

A more pronounced reaction was obtained by igniting bits of tissue and triturating the residue on the glass plate with a 10 per cent solution of hydrochloric acid. The liquid was then drained off, a large drop of $NaH(NH_4)PO_4$ applied, and the slide allowed to remain for several minutes in an atmosphere of ammonia.

Positive results were obtained when these tests were applied to both lighter and darker areas.

POTASSIUM

The most reliable test for potassium is its reaction with platinic chloride, resulting in the formation of crystals of potassium chloroplatinate. A 10 per cent solution of platinic chloride is recommended for this test. The sections to be tested were mounted in a drop of alcohol, and a drop of platinic chloride about one-tenth the size of the drop of alcohol was placed on the slide. The reagent and alcohol mount were then brought into communication by means of a glass needle. After several minutes crystals of potassium chloroplatinate, mainly in the form of octahedrons, but also in the form of hexahedrons and rhombohedrons, separated out.

This result was checked by applying a test solution consisting of 2 grams of cobalt nitrite and 3.5 grams of sodium nitrite dissolved in 1 cc. of acetic acid diluted with water to 7.5 cc. After the cessation of the liberation of nitric oxide fumes, the solution was diluted to a volume of 10 cc. Upon the application of this reagent to sections, minute granules of potassium cobalt nitrite separated out. The crystals were extremely small and were detected with difficulty.

These tests were applied with equal success to both diseased and healthy tissue.

PHOSPHORUS

Phosphorus is generally detected by means of a solution of 1 gram of ammonium molybdate in 12 cc. nitric acid (sp. gr. 1.18). In the presence of phosphorus, granules or small octahedrons of ammonium phosphomolybdate separate out.

A second test described for the detection of phosphorus is its precipitation as ammonium magnesium phosphate. The solution used for the determination consists of 25 volumes of a saturated aqueous solution of magnesium sulphate, 2 volumes of a saturated aqueous solution of ammonium chloride, and 15 volumes of water. This solution when applied to salts of phosphorus yields crystals of ammonium magnesium phosphate such as were described above under magnesium.

The writer was unable to get uniform results with either of these tests, regardless of the kind of tissue to which they were applied. When samples of diseased and healthy tissue were ignited a faint indication of the presence of crystals was detected at intervals in the residue, but the results on the whole were not encouraging. Because of the fact that this was experienced with healthy and normal tissue to the same degree as with diseased tissue, we may be justified in concluding that the disorder cannot be attributed to a marked unbalanced phosphorus relation.

SULPHUR

Sulphur is absolutely essential for plant growth, usually being present in organic combination. When present in inorganic form it may be detected as calcium sulphate by means of calcium acetate, or as lead sulphate with lead acetate, or as barium sulphate with barium chloride. Organic sulphur can best be detected after its liberation by ignition of the tissue.

The tests for sulphur gave results much the same as those for phosphorus. It was difficult to demonstrate its presence even in normal healthy tissue, and we are therefore unable to correlate any metabolic disturbance with a lack or a superabundance of this element.

TESTS FOR CARBOHYDRATES

From the marked difference in chlorophyll content of the lighter and darker areas of diseased leaves, it seemed self-evident that there must be a great difference in the carbo-

hydrate content. Tests were therefore made for starch and sugar as described below.

The material to be examined was cut into thin sections, consisting entirely of either lighter or darker tissue, or, in order to make the comparison more striking, in part of dark tissue and in part of light tissue.

Starch.—Tests for starch were made by mounting the section in water and drawing the slide through the flame of a micro-burner until the drop of water began to simmer. This not only killed the cells, but also expelled the air from the intercellular spaces, thus making observation easier. A drop of 75 per cent alcohol and a drop of standard iodine were then added, after which the section was examined under the microscope and the amount of starch noted. In general, it may be stated that whenever cells of the same section composed of different leaf areas, or cells of the same section representing adjacent differentiated areas were compared, there was an excess of starch in the dark green tissue. When testing for starch in the manner described, one cannot misinterpret the observations. It would be aside the point to offer the criticism that the difference in starch content may be attributed to the location of the tissue tested in different parts of the plant, to a probable shading of one tissue and not the other, to a difference in the age and therefore a difference in the storage and in the photosynthetic activity, or to other environmental factors. Any difference exhibited in cells of the same section representing different areas must be due to factors inherent in the tissue. This excess of starch in the green tissue was noticed regardless of the time of day when tests were made.

Woods ('02) cites an experiment which led him to conclude that starch was not translocated readily from the chlorotic areas, and attributed this fact to the inhibitory action exerted on diastase by oxidizing enzymes. The leaves were picked early in the morning and tested for starch by immersing in boiling water for one minute, decolorizing with alcohol, treating with iodine solution, and examining by transmitted light. A darker color, presumably, was assumed by

the chlorotic spots. It was also observed that when unboiled juice from tobacco leaves, possessing strong oxidase activity, was added to a digestion mixture of starch and taka-diastase, no diastatic action took place. When the juice was boiled and the oxidizing enzyme was killed before addition to the digestion mixture, diastatic action occurred. Combining these observations, Woods concluded that the inability of the chlorotic spots to rid themselves of their starch, as seemed to be demonstrated by his tests, was attributable to the action of oxidases on diastase.

In order to test this idea of Woods more conclusively, the writer examined diseased leaves early in the morning by the method described above, but always found an excess of starch in that portion of the section representing the darker area. Plants were then placed in the dark room and kept there for 54 hours. At the end of this time sections were cut and examinations made for starch. Observations on a number of leaves and a large number of sections showed that at the end of this period no starch whatever was present in the lighter or chlorotic areas, while the mesophyll of the darker areas still contained varying amounts. This, then, is in accord with the general observation that the dark tissue contains more starch regardless of the time of day when tests are made. It is quite probable that oxidizing enzymes may influence the activity of diastase, but when adding a strong extract from diseased tobacco leaves to a starch digestion mixture, we are adding innumerable unknown factors, the effects of which might easily be confused with those exhibited to a more or less pronounced degree by one of the known constituents when added alone in a pure state.

Sugar.—A microchemical test for sugar which has been long employed is the production of a fine red precipitate when treated with dilute Fehling's solution. Sections of tissue were placed on the slide, a drop of Fehling's solution added, and the mount warmed gently over a flame. No satisfactory results were obtained, which, in part at least, might be attributed to the great diffusibility of the sugar out of the cells as soon as they were killed and the difficulty with which the

small quantity may be detected in the test solution bathing the section.

A more reliable method is the one based on the reactions of sugars with phenylhydrazine to form osazones. This method has been developed most satisfactorily by Manghan ('15). Although the method may be criticized as to the reliability of the anticipated reaction of any one sugar in the presence of other sugars and as to the justification of attributing certain results to the reaction of the reagent with any one carbohydrate when other sugars are present, it nevertheless serves as a pretty fair qualitative test. Separate solutions of phenylhydrazine hydrochloride and sodium acetate were prepared by dissolving these reagents in sufficient pure sugar-free glycerin to make a 10 per cent solution. Small drops of these solutions were placed on the slide, mixed with a glass needle, and in this the sections to be tested were immersed. The mount was then covered with a cover glass and the preparation heated for an hour at 100° C. At the end of this period and continuing for several days, yellow bodies, resembling the droplets of syrup described by Manghan for maltose, and the small yellow spheres and granules figured by Molisch and Tunmann, separated out. The reaction was more pronounced in the darker areas of diseased leaves than in the lighter tissue.

From the results reported above it is very evident that one great difference between the dark green and chlorotic areas of diseased tissue is a difference in the carbohydrate content, there being more in the former than in the latter.

It was originally intended to accompany the above descriptions with adequate illustrations and to make similar tests on all varieties of plants showing mosaic. Microchemical methods, however, are very difficult, requiring the finest technique and the greatest care in observation and interpretation. Since, therefore, a general microchemical study of plants affected with mosaic is in reality a problem in itself, and also because of the nature of the results reported above, the microchemical work was deferred for the time being for

a line of experimentation which seemed more fundamental. The tests described above were carried out on diseased and healthy tobacco plants. The results are primarily relative, yet the relativity is to a certain degree quantitative, and enough so to justify us in concluding that calcium and nitrogen may be more abundant in the chlorotic areas, while carbohydrates are more plentiful in the green tissue. The cause of this unbalanced condition is not apparent at present. It is essential, however, that all these observations be substantiated by reliable quantitative analyses.

Physiological Relations

From the results reported above, and especially those relating to the inorganic constituents of the tissue, it is very evident that the real cause of the disease is more deeply seated than has been intimated in some literature on mosaic diseases. There is therefore reason to believe that the cause, if not associated with parasites, is essentially organic in nature, as is suggested by the work of Woods ('02) and others.

Woods ('02) maintained that mosaic diseases could be attributed to an excess of oxidases, since a more pronounced oxidase reaction was evidenced by diseased plants, and also when ridding his extract of oxidases, he lost the infective mosaic principle. However, this may not be the right interpretation, and to the writer this increase in oxidase reaction seemed to be an effect and not a cause of the disease. We would not conclude that the diminished sugar content of the lighter areas of the tissue as compared with that in the darker areas is responsible for the disease, but rather that this, as also the difference in oxidase activity, is in reality only the result of the disorder.

The writer therefore undertook to eliminate the oxidases from extracts of diseased plants without destroying their infectious properties, or, if it were possible, to secure a solution which from the start possessed infectious properties but no oxidase activity. Since Allard ('14, '15) has shown that the infective principle may be obtained from all parts of the plant

including the root system, and since it has been repeatedly stated in the literature that plants grown on land which had borne diseased plants were sure to contract the disease, an attempt was made to secure a root secretion possessing infectious properties. Roots were washed free from soil and then suspended in sterile distilled water. This method had to be abandoned, however, on account of bacterial growth.

Since the disease is most pronounced in growing tissue, i. e., in young shoots, and since the infective principle may be isolated from the roots as well as from all parts of the plant, it must be granted that the infectious substance is transferable from one plant part to another. This implies that some of the infectious substance, originally in a highly diseased shoot or any which might be formed subsequently, might be transferred to other plant parts. The question then arose: If this assumption is correct, would it be possible to secure by "shoot secretion" or by "shoot exudation" a solution possessing infectious properties? Furthermore, would any oxidases be present in this secretion?

An attempt was made to solve the question in the following manner: A large but badly diseased shoot of tobacco was removed from an old plant and after sterilizing the base with alcohol and rinsing with sterile distilled water, it was supported, through a rubber stopper, in a wide-mouthed bottle containing sterile distilled water. A piece of glass tubing inserted into a small hole in the rubber stopper served as an inlet for sterile water stored in a separatory funnel. All joints were closed tightly with paraffin and wax. The bottle containing the base of the shoot was filled with water, leaving no air whatever in the chamber. As the water was removed by transpiration it was replenished from the separatory funnel serving as a reservoir. This funnel was stoppered with a one-holed rubber stopper into which a piece of glass tubing stuffed with cotton was inserted.

The system was allowed to run from April 1 to April 19, 1916, at the end of which time the shoot had transpired 485 cc. of sterile water. Inoculations were made on April 19, 1916, with the secretion, and checks were run with juice ex-

pressed from diseased leaves and filtered through Berkefeld filters, and with sterile water. Four plants were used in each case. At the end of 17 days, 3 plants inoculated with the secretion were diseased, while all 4 of the plants inoculated with the filtered juice of diseased leaves showed mosaic. The 4 checks remained healthy.

This experiment was repeated on July 7, 1916, an entire plant being used for secretion. This necessitated the use of larger vessels, etc., which increased chances for contamination. The secretion obtained in this case had been badly fermented by bacteria, and inoculation experiments gave negative results.

The writer's time then became occupied with a field experiment and a repetition of the above had to be deferred. It was repeated, however, on September 6, 1916, the secretion phase of the experiment being allowed to run until October 19. Inoculations were made on October 22, 6 plants being used. After 15 days 2 of the 6 plants inoculated with the secretion showed mosaic, while all 6 inoculated with sterile tap water were healthy. Inoculations were not made with juice of diseased leaves as in the first experiment. There is reason to believe, from the uniformity of the results obtained with secretions, that some of the infectious substance was dissolved in the sterile water used for subsequent inoculations. Each secretion was tested for oxidases by adding hydrogen peroxide and guaiacum, as did Woods, but no oxidases were detected. No indisputable conclusions could be drawn from these results, since these experiments were only preliminary, but because of their uniformity, they furnished considerable encouragement towards investigating further the possibility of securing an extract possessing infectious properties but no oxidase activity.

On *a priori* grounds it seemed scarcely possible that substances such as oxidases found naturally and so commonly in plants should, when injected into other plants, be able to produce such a disorder as the mosaic disease. It will be recalled that Allard ('15[a]) was able to produce the disease even at a dilution of 1:10,000. One can easily see, however, how a sub-

stance naturally "toxic" to a plant might, even in extreme dilution, cause serious metabolic disturbances. During the time that the above work was deferred on account of another phase of the problem, an article was published by Allard ('16[a]) on some of the properties of the infective principle which showed conclusively that the mosaic disease of tobacco is not caused by oxidases but, according to Allard's interpretation, is caused by an ultramicroscopic parasite. The writer's preliminary work substantiates the more elaborate experiments of Allard, thus eliminating oxidases as a cause of the disease. I do not, however, concur with him in the interpretation of the properties of the infective principle, as will be noted later on.

Plot Experiments

A great deal of interest has been aroused recently by the mosaic diseases of cucurbits, particularly of cucumber. During the spring of 1916 cucumbers grown in the experimental greenhouse contracted the disease, and an experiment was planned to test its transmissibility not only to other cucurbits but also to other plants susceptible to the malady. All seeds were started in the greenhouse and later transplanted to the plot.

Injury to seedling at the time of transplanting has often been cited as predisposing plants to the disease, and it therefore became desirable to eliminate this factor. Tobacco seed was sown in flats and after 10 days the seedlings were transplanted to small paper boxes. The cotyledons had just expanded at the time of transplanting, and the entire plant measured about $\frac{1}{2}$–$\frac{3}{4}$ inches in length. Although exceedingly small, the seedlings could be handled without injury other than probably the destruction of a few root hairs. The paper boxes to which the plants were transferred were $2\frac{1}{2}$ inches long, $1\frac{1}{4}$ inches wide, and about 2 inches deep. When the plants were large enough to be transplanted to the plot, the entire box was submerged in the soil. This eliminated all possible chances for injury. Tomato seedlings were obtained by planting the seed in flats and handling the seedlings in the

manner described for tobacco, or the seed was sown directly in the paper boxes, as was the case with the cucurbits. Later in the season seeds were also planted directly in the soil. During the growing season the plants were cultivated with the greatest care in order to avoid injury. All plants which were damaged were either discarded or labeled so that any inconsistency in results might receive its proper explanation. The cucurbits grown included 2 varieties of pumpkins, 2 of squash, 2 of watermelon, 2 of cucumber, and 1 variety of citron, muskmelon, and cassaba. At the end of 2 months, when the plants had developed several runners, inoculations were made with an extract from diseased cucumbers. In cases where runners were numerous, 3 or 4 inoculations were made on the same plant, the total on all varieties summing up to 213. Not a single infection resulted from these inoculations.

Before offering an explanation it will be necessary to give some details regarding the preparation of the extract. For this purpose 500 grams of highly diseased shoots were gathered from diseased cucumber plants. The material was first washed in tap water and then rinsed in distilled water. Maceration was effected by placing portions of this material in a large mortar and pounding, crushing, and grinding the leaves and stems until all had been reduced to a pulp. The juice was then expressed through a cloth, and the residue washed with water until the original extract and the washings totaled 500 cc. An attempt was then made to filter off the substances suspended in the extract; but due to exceedingly slow filtration, other means had to be resorted to. An asbestos mat was therefore deposited in a Buchner funnel, which in turn was connected with a filter flask and filter pump. The filter, however, soon became clogged and filtration was not effected with the desired rapidity. The entire extract, asbestos and all, was therefore placed in centrifuge tubes and centrifugated until all the suspended material had been deposited. The supernatant liquid, which was of a slightly greenish color, was used for inoculations. About fifteen hours

elapsed between the time that the material was gathered and the time when inoculations were made.

As has already been stated, no infections resulted from these inoculations, and the experiment is of absolutely no value as far as throwing further light upon the transmissibility of cucumber mosaic to other cucurbits; but it does afford the writer an opportunity to criticize the technique involved, to point out probable sources of error, and to lay special emphasis upon the amount of care which must be exercised when dealing with something, the nature of which is so incompletely known.

If the infective principle is of the nature of an organism, one can easily see how the parasite might have been destroyed mechanically during the maceration of the tissue. Fred ('16), for example, has been able to reduce the number of bacteria in 1 gram of dry soil from 2,000,000 to 400,000 by grinding for 1 hour. In another instance the number was reduced from 3,194,000 to 75 by grinding for 24 hours.

Allard ('16[a]) found that the "virus" was extremely sensitive to the antiseptic properties of formaldehyde. Warner ('14) has demonstrated that formaldehyde is one of the oxidation products of chlorophyll extracts. The loss of the infectious properties of the cucumber extract used for inoculating might, in the absence of any proof whatever, be accounted for in this manner.

If the infective principle is of the nature of an enzyme or colloidal substance it is also possible, as with bacteria, that destruction took place through mechanical agitation. It is a well-known fact that many colloids, especially suspensoids, are thrown out of the colloidal equilibrium by mechanical agitation. This fact was furthermore demonstrated by Brown ('15) working on the macerating and lethal enzymes of *Botrytis cinerea*. He found that this action could be reduced eight-ninths by simply bubbling air through the extract for 45 minutes. Allard ('16[a]) also found that the "virus" was greatly adsorbed by talc. Whether or not the adsorptive power of the asbestos used, coupled with centrifugation, can account for the removal of the infective principle from the

extract is of course unknown, but this is another possibility.

Although no infections could be attributed to inoculations with the cucumber extract, the disease was, during the season, contracted by plants of pumpkin, squash, citron, cassaba, and two varieties of cucumbers. Some observations in this connection are also reported by Doolittle ('16).

Temperature and Moisture Relations

Although it is occasionally stated in the literature on mosaic diseases that high temperature favors the disease, there are, nevertheless, no quantitative data nor detailed experiments to substantiate this view. An interesting observation in this connection was made during the summer of 1916. Tomato plants which had been transplanted to the plot grew normally until the latter part of July when, due to drought and high temperature, they discontinued growing but otherwise appeared perfectly normal. These climatic conditions continued until the middle of August when several rains occurred which were followed, though not immediately, by comparatively cool weather. It was during these 10 days of cool weather, from August 23 to about September 2, that mosaic began to show on the tomato plants. During this period growth was resumed and all new shoots and buds were noticeably affected.

Following this comparatively cold period, there was another hot spell during which there not only was a high departure from the normal but the maximum for the individual days was higher, reaching 94° F. During this second, though relatively short, warm period accompanied by reduced precipitation growth ceased and the mosaic began to disappear. The chlorotic areas became darker, and the small amount of expansion which did take place in the leaves of the new shoots was not accompanied by malformations. Had it not been for the fact that the plants were under constant observation, the periodic occurrence of mosaic would have escaped notice entirely. No records pertaining to temperature and moisture were taken on the plot, but the following tables from the U. S. Department of Agriculture Weather Report present the

monthly meteorological summaries for St. Louis. Although these values are not absolute as regards weather conditions on the plot, they are sufficiently accurate to indicate the climatic differences during these time periods.

TABLE I

METEOROLOGICAL SUMMARY FOR JULY, 1916

DAY	TEMPERATURE (Degrees Fahrenheit)				MOISTURE			SUNSHINE		CHARACTER OF DAY
	Highest	Lowest	Mean	Departure from normal	Relative humidity percentage 7 a. m.	Relative humidity percentage 7 p. m.	Total precipitation (midt. to midt., inches)	Number of hours	Percentage of possible	
1	94	78	86	+ 8	65	53	.00	13.0	87	Clear
2	96	78	87	+ 9	66	46	.00	14.8	100	Clear
3	94	72	83	+ 5	64	65	.04	9.8	66	Pt. cloudy
4	86	69	78	0	76	52	.00	13.0	88	Clear
5	86	70	78	0	57	44	.00	14.8	100	Clear
6	87	69	78	0	58	42	.00	14.8	100	Clear
7	89	70	80	+ 1	67	52	.00	14.1	95	Clear
8	91	76	84	+ 5	73	40	.00	14.5	98	Clear
9	87	68	78	− 1	79	50	.00	14.7	99	Clear
10	88	66	77	− 2	74	42	.00	14.8	100	Clear
11	92	73	82	+ 3	68	47	.00	14.7	100	Clear
12	92	72	82	+ 3	61	70	.34	5.8	39	Pt. cloudy
13	95	72	84	+ 5	86	48	.00	14.7	100	Clear
14	92	77	84	+ 5	73	67	.00	9.9	67	Clear
15	94	77	86	+ 7	79	44	.00	14.3	98	Clear
16	97	80	88	+ 9	62	59	.01	11.1	76	Clear
17	96	79	88	+ 9	74	54	.00	6.8	47	Pt. cloudy
18	94	76	85	+ 6	78	55	T.	8.4	58	Pt. cloudy
19	94	70	82	+ 3	78	74	.81	9.2	63	Pt. cloudy
20	92	74	83	+ 4	83	68	.00	12.4	86	Clear
21	90	75	82	+ 2	87	41	.00	12.5	86	Clear
22	90	74	82	+ 2	59	35	.00	14.5	100	Clear
23	94	75	84	+ 4	48	48	.00	14.0	97	Clear
24	97	79	88	+ 8	55	52	.00	14.4	100	Clear
25	97	78	88	+ 8	63	44	T.	11.1	77	Clear
26	98	78	88	+ 8	62	45	.00	12.5	87	Clear
27	97	81	89	+ 9	65	41	.00	14.1	99	Clear
28	98	79	88	+ 8	68	52	.00	14.3	100	Clear
29	96	80	88	+ 8	75	44	.00	14.3	100	Clear
30	99	82	90	+11	73	46	.00	11.4	80	Pt. cloudy
31	99	79	89	+10	74	67	T.	12.1	85	Pt. cloudy

It is of course impossible to say whether this phenomenon should be attributed entirely to temperature relations or whether it was also determined, in part at least, by water relations. Many writers have reported that moisture seems to

favor the disease and that infection seems to be worse in plants growing in moist, clayey soil. There are, however, no quantitative data on the water requirements of healthy and diseased plants. On studying the weather chart, one can

TABLE II

METEOROLOGICAL SUMMARY FOR AUGUST, 1916

DAY	TEMPERATURE (Degrees Fahrenheit)				MOISTURE			SUNSHINE		CHARACTER OF DAY
	Highest	Lowest	Mean	Departure from normal	Relative humidity percentage 7 a. m.	Relative humidity percentage 7 p. m.	Total precipitation (midt. to midt., inches)	Number of hours	Percentage of possible	
1	89	72	80	+ 1	75	62	.00	11.1	78	Clear
2	90	71	80	+ 1	83	71	.34	7.0	49	Pt. cloudy
3	94	73	84	+ 5	87	47	.00	12.8	91	Clear
4	96	77	86	+ 7	81	56	.00	13.4	95	Clear
5	94	78	86	+ 7	81	58	.00	14.0	100	Clear
6	93	77	85	+ 6	79	48	.00	12.9	92	Clear
7	94	72	83	+ 4	70	57	.27	9.7	69	Pt. cloudy
8	87	73	80	+ 1	89	69	.36	6.8	49	Pt. cloudy
9	90	73	82	+ 3	96	77	.00	12.9	93	Clear
10	93	76	84	+ 5	87	64	T.	11.0	79	Clear
11	94	70	82	+ 4	79	62	.94	11.6	83	Pt. cloudy
12	91	69	80	+ 2	95	72	2.10	9.3	67	Pt. cloudy
13	73	67	70	— 8	98	75	.99	1.2	9	Cloudy
14	74	59	66	—12	100	91	3.67	2.3	17	Cloudy
15	85	67	76	— 2	100	74	1.73	7.8	57	Pt. cloudy
16	85	71	78	0	95	76	.00	9.2	67	Pt. cloudy
17	94	75	84	+ 7	89	67	.00	13.5	99	Clear
18	95	78	86	+ 9	78	56	.00	11.7	86	Clear
19	94	80	87	+10	72	60	.00	11.0	81	Pt. cloudy
20	96	80	88	+11	72	57	.00	11.9	88	Clear
21	94	77	86	+10	70	59	.00	10.1	75	Clear
22	85	66	76	0	77	63	T.	5.8	43	Pt. cloudy
23	80	61	70	— 6	74	48	.00	13.4	100	Clear
24	85	66	76	0	67	44	.00	13.4	100	Clear
25	88	68	78	+ 2	68	55	.00	13.3	100	Clear
26	86	65	76	+ 1	85	70	.20	5.4	41	Pt. cloudy
27	71	61	66	— 9	87	75	.09	0.8	6	Cloudy
28	75	55	65	—10	74	48	.00	10.1	77	Pt. cloudy
29	78	63	70	— 5	65	57	.00	11.1	84	Pt. cloudy
30	83	65	74	0	68	56	.00	11.9	91	Clear
31	84	66	75	+ 1	71	55	.00	10.6	81	Pt. cloudy

easily see how the above observation might also be explained on the basis of moisture relations, but this is not substantiated by the experiment next described.

On January 29, 1917, 6 badly diseased tomato plants were

placed in each of 2 separate compartments in the experimental greenhouse, one of which was kept at 75–95° F. (average 85° F.), while the other was held at a temperature of 35–50° F. (average about 45°).[1] After a period of 7 to 10

TABLE III

METEOROLOGICAL SUMMARY FOR SEPTEMBER, 1916

DAY	TEMPERATURE (Degrees Fahrenheit)				MOISTURE			SUNSHINE		CHARACTER OF DAY
	Highest	Lowest	Mean	Departure from normal	Relative humidity percentage 7 a. m.	Relative humidity percentage 7 p. m.	Total precipitation (midt. to midt., inches)	Number of hours	Percentage of possible	
1	74	66	70	— 4	83	95	.37	0.2	2	Cloudy
2	83	65	74	0	99	73	.00	7.4	57	Clear
3	85	67	76	+ 2	94	70	.00	11.0	85	Clear
4	90	69	80	+ 7	88	59	.00	8.6	67	Pt. cloudy
5	94	73	84	+11	82	55	.00	12.9	100	Clear
6	93	71	82	+ 9	78	52	.00	12.8	100	Clear
7	91	66	78	+ 5	71	86	.89	7.5	59	Pt. cloudy
8	78	67	72	0	90	63	.00	9.8	77	Pt. cloudy
9	80	63	72	0	80	62	.00	11.2	88	Clear
10	84	64	74	+ 2	82	60	.00	10.9	86	Clear
11	85	70	78	+ 7	86	76	.00	9.8	78	Pt. cloudy
12	79	66	72	+ 1	87	79	.10	3.7	29	Cloudy
13	70	63	66	— 5	75	66	.00	5.0	40	Cloudy
14	77	55	66	— 5	92	70	.00	12.5	100	Clear
15	64	49	56	—14	71	56	.00	12.5	100	Clear
16	72	49	60	—10	71	55	.00	12.0	97	Clear
17	67	53	60	—10	77	70	T.	11.4	92	Clear
18	64	48	56	—13	61	52	.00	12.3	100	Clear
19	72	52	62	— 7	53	49	.00	12.3	100	Clear
20	79	54	66	— 3	63	58	.22	4.3	35	Cloudy
21	76	61	68	0	62	52	.00	9.8	80	Clear
22	73	56	64	— 4	55	65	.00	12.2	100	Clear
23	71	51	61	— 7	73	53	.00	12.1	100	Clear
24	77	56	66	— 1	72	62	.00	7.3	60	Pt. cloudy
25	86	61	74	+ 7	84	47	.00	12.0	100	Clear
26	86	67	76	+ 9	81	51	.00	10.5	88	Clear
27	83	65	74	+ 8	69	100	1.11	6.4	53	Cloudy
28	65	46	56	—10	85	70	T.	0.4	3	Cloudy
29	59	41	50	—16	77	54	.00	11.9	100	Clear
30	63	45	54	—12	63	60	.00	11.8	100	Clear

days the plants in the room kept at high temperature showed less mottling, while 40 days later, at the time of this writing,

[1] The temperature values are given in terms of Fahrenheit in order to facilitate comparison with the temperatures recorded in the meteorological summaries.

no mottling whatever can be detected. The plants in the compartment kept at 45° F., at this time, still show a great deal of mottling. The writer has not had time to carry on inoculation experiments. Ten tobacco plants were also placed in each

TABLE IV

METEOROLOGICAL SUMMARY FOR OCTOBER, 1916

DAY	TEMPERATURE (Degrees Fahrenheit)				MOISTURE			SUNSHINE		CHARACTER OF DAY
	Highest	Lowest	Mean	Departure from normal	Relative humidity percentage 7 a. m.	Relative humidity percentage 7 p. m.	Total precipitation (midt. to midt., inches)	Number of hours	Percentage of possible	
1	68	45	56	— 9	72	49	.00	11.8	100	Clear
2	74	50	62	— 3	80	52	.00	11.8	100	Clear
3	79	54	66	+ 1	70	56	.00	11.7	100	Clear
4	81	57	69	+ 5	61	49	.00	11.7	100	Clear
5	84	62	73	+ 9	59	44	.00	9.8	84	Clear
6	82	60	71	+ 8	91	55	.00	11.6	100	Clear
7	86	65	76	+13	78	57	.00	11.5	100	Clear
8	84	67	76	+14	79	64	.00	5.5	48	Pt. cloudy
9	72	48	60	— 2	88	71	T.	0.0	0	Cloudy
10	59	42	50	—12	85	51	.00	11.4	100	Clear
11	65	46	56	— 5	63	46	.00	8.5	75	Pt. cloudy
12	78	54	66	+ 5	54	61	T.	6.1	54	Cloudy
13	69	55	62	+ 2	76	42	.00	9.2	81	Pt. cloudy
14	68	48	58	— 2	69	49	.07	6.4	57	Pt. cloudy
15	59	52	56	— 3	100	93	.22	0.0	0	Cloudy
16	75	55	65	+ 6	94	75	.01	4.1	37	Cloudy
17	60	46	53	— 5	71	48	.00	11.1	100	Clear
18	53	45	49	— 9	80	100	.33	0.0	0	Cloudy
19	58	38	48	— 9	95	100	.27	0.0	0	Cloudy
20	39	31	35	—22	94	84	.05	0.0	0	Cloudy
21	51	30	40	—16	78	58	.00	11.0	100	Clear
22	65	38	52	— 4	70	60	.00	10.5	96	Clear
23	68	45	56	+ 1	69	54	.00	9.3	85	Clear
24	73	53	63	+ 9	64	53	.00	4.1	38	Pt. cloudy
25	62	45	54	0	86	58	.01	6.0	56	Pt. cloudy
26	64	40	52	— 1	85	40	.00	8.2	76	Clear
27	71	52	62	+ 9	54	47	.00	10.7	100	Clear
28	75	54	64	+12	65	38	.00	6.8	64	Pt. cloudy
29	75	54	64	+12	61	51	T.	4.0	38	Pt. cloudy
30	74	50	62	+11	94	74	.68	8.8	83	Clear
31	64	50	57	+ 7	82	76	.00	10.6	100	Clear

compartment, but the results with tobacco were somewhat different, since the plants differ physiologically from tomatoes.

The tobacco plants kept at 85° F. remained diseased, while those kept at 45° showed at least temporary recovery. This

is illustrated in pl. 14. Plant No. 2 was kept at 85° F. and shows the young leaves passing through a venation stage into true mottling. Plant No. 1 kept at 45° F. shows the reverse. Mottled leaves pass through the venation stage into an ap-

TABLE V

METEOROLOGICAL SUMMARY FOR NOVEMBER, 1916

DAY	TEMPERATURE (Degrees Fahrenheit)				MOISTURE			SUNSHINE		CHARACTER OF DAY
	Highest	Lowest	Mean	Departure from normal	Relative humidity percentage 7 a. m.	Relative humidity percentage 7 p. m.	Total precipitation (midt. to midt., inches)	Number of hours	Percentage of possible	
1	71	47	59	+ 9	58	42	.00	10.5	100	Clear
2	67	51	59	+10	58	26	.00	10.5	100	Clear
3	66	48	57	+ 8	46	36	.00	1.2	12	Pt. cloudy
4	79	60	70	+22	66	58	.00	7.4	71	Clear
5	79	59	69	+21	76	74	.00	10.4	100	Clear
6	76	56	66	+19	79	44	.00	10.4	100	Clear
7	75	59	67	+20	71	52	.00	10.3	100	Clear
8	71	53	62	+16	76	59	.63	1.4	14	Cloudy
9	56	44	50	+4	91	29	.10	7.4	73	Clear
10	67	44	56	+11	64	47	.00	10.2	100	Clear
11	62	41	52	+7	90	56	.00	10.2	100	Clear
12	57	39	48	+4	89	78	.00	6.5	64	Cloudy
13	39	22	30	—14	93	76	.05	0.0	0	Cloudy
14	29	15	22	—21	75	54	.00	10.1	100	Clear
15	34	20	27	—16	72	41	.00	10.0	100	Clear
16	53	25	39	— 4	72	43	.00	10.0	100	Clear
17	48	31	40	— 2	78	46	.00	6.3	63	Pt. cloudy
18	51	28	40	— 2	86	39	.00	10.0	100	Clear
19	68	42	55	+13	62	34	.00	9.9	100	Clear
20	68	44	56	+14	56	41	.00	9.9	100	Clear
21	49	36	42	+ 1	91	86	T.	0.0	0	Cloudy
22	55	46	50	+ 9	77	93	1.29	0.0	0	Cloudy
23	53	38	46	+ 6	89	70	.46	1.2	12	Cloudy
24	39	30	34	— 6	66	45	.00	9.8	100	Clear
25	43	26	34	— 6	70	44	.00	8.4	86	Pt. cloudy
26	56	35	46	+ 6	55	37	.00	9.8	100	Clear
27	58	42	50	+11	42	47	.00	6.0	62	Pt. cloudy
28	60	50	55	+16	88	79	.00	1.3	13	Cloudy
29	56	46	51	+12	91	41	.00	9.7	100	Clear
30	55	36	46	+ 7	66	28	.00	9.6	100	Clear

parently healthy stage, while the young leaves show but a slight venation and are nearly healthy. It was impossible to keep the temperature of this room down to 45° F. during and after the early part of March, and it occasionally reached

84° F. The plants which showed apparent recovery at the low temperature grew vigorously and showed some mottling.

A single potato plant which had contracted the disease was discovered in the greenhouse, and this was placed in the room

TABLE VI

METEOROLOGICAL SUMMARY FOR DECEMBER, 1916

DAY	TEMPERATURE (Degrees Fahrenheit)				MOISTURE			SUNSHINE		CHARACTER OF DAY
	Highest	Lowest	Mean	Departure from normal	Relative humidity percentage 7 a. m.	Relative humidity percentage 7 p. m.	Total precipitation (midt. to midt., inches)	Number of hours	Percentage of possible	
1	58	40	49	+10	55	44	.00	9.6	100	Clear
2	60	41	50	+12	62	52	T.	8.0	83	Clear
3	68	49	58	+20	78	74	.00	7.0	73	Pt. cloudy
4	71	58	64	+26	81	53	T.	6.6	69	Pt. cloudy
5	59	45	52	+14	61	24	.00	6.8	71	Clear
6	57	39	48	+10	41	32	.00	7.1	74	Clear
7	69	50	60	+23	81	92	.37	0.0	0	Cloudy
8	58	29	44	+ 7	89	79	.57	0.0	0	Cloudy
9	38	24	31	— 6	72	56	.00	9.5	100	Clear
10	38	28	33	— 3	82	55	T.	5.8	61	Pt. cloudy
11	36	24	30	— 6	83	89	.02	0.0	0	Cloudy
12	30	17	24	—12	84	82	T.	1.0	11	Cloudy
13	20	7	14	—22	71	76	.00	3.1	33	Cloudy
14	19	7	13	—23	83	83	.07	0.0	0	Cloudy
15	26	2	14	—22	87	56	T.	6.2	66	Pt. cloudy
16	52	16	34	— 1	72	61	.00	9.4	100	Clear
17	38	27	32	— 3	92	63	T.	0.0	0	Cloudy
18	30	19	24	—11	66	64	T.	6.0	64	Clear
19	40	23	32	— 3	71	80	.00	0.4	4	Cloudy
20	23	10	16	—19	94	68	.02	1.9	20	Cloudy
21	12	8	10	—24	84	88	.04	0.0	0	Cloudy
22	21	2	12	—22	79	64	.00	9.4	100	Clear
23	36	18	27	— 7	85	78	.01	6.5	69	Cloudy
24	47	30	38	+ 4	77	60	T.	7.1	76	Pt. cloudy
25	38	26	32	— 2	82	69	.00	9.4	100	Clear
26	58	37	48	+14	98	98	1.06	0.0	0	Cloudy
27	46	29	38	+ 5	82	73	.00	6.1	65	Pt. cloudy
28	35	26	30	— 3	69	52	.00	9.4	100	Clear
29	31	22	26	— 7	63	55	.00	9.4	100	Clear
30	34	22	28	— 5	66	59	.00	9.5	100	Clear
31	40	24	32	0	69	59	T.	6.9	73	Pt. cloudy

kept at 85° F. At the end of 10 days nearly all mottling had disappeared, and the plant was then placed in the room kept at 45°. At the time of transfer, the sprouts which had been trailing on the ground were tied up. The leaves gradually

began to drop off, presumably due to excessive transpiration, until only a few remained at the top. These later became chlorotic, but they were not uniformly colored, being speckled with green areas. Whether or not this can be interpreted as a recurrence of the disease or merely an unmasking of the formerly diseased areas cannot be stated positively, but it probably is the latter. The plant died shortly after this last observation was made. The case of this potato plant is, of course, but a single instance, but it is entirely in accord with the other observations.

No record was kept of the amount of water supplied to the plants in the various experiments. They were all watered according to their normal needs under greenhouse conditions. The greenhouse observations substantiate those on the plot. When the tomatoes on the plot showed no mosaic, the tobacco and some of the cucurbits were greatly mottled.

It therefore not only seems that individual plants exhibit an optimum for the mosaic in accordance with the optimum of their growth, but that there also may be a maximum beyond which little or no mosaic is manifested. If this is true we should also find a minimum, and some very interesting observations have been made in this direction. In a recent article, Brierley ('16) reports recovery of tomato plants from mosaic. Inoculations were made by him, but he states that "unfortunately the plant was killed outright by frost ten days later, at that time showing no sign of disease." From this we would conclude that the plant was kept in a comparatively cool place. This same phenomenon was observed in tobacco plants kept at 45° F., as has been stated above and shown in pl. 14.

Another observation was made in the fall of 1916. Plate 15, fig. 1, shows two plants (*b* and *c*) which are the same age, the one perfectly healthy, the other presumably affected with mosaic. On November 20 plant *b* was removed to a greenhouse to which no heat was supplied. The photograph of plant *a* was taken on December 13, 1916, after which plant *b* was placed in a greenhouse maintained at 65–75° F. in order to note a probable recurrence of the disease. The plant, however, remained healthy and fruited normally. No

greenhouse records are available for the cool greenhouse, but since no heat was supplied, the temperatures were in the neighborhood of those recorded in the monthly meteorological summaries given above.

The question, of course, arises as to whether plant *b* is really affected with mosaic. The leaves are not truly mottled, but are venated. The malformation is characteristic, particularly of some of the new shoots appearing on old diseased tobacco plants. When discussing the effect of temperature on the plants shown in pl. 14, it was stated that the leaves passed through the venation stage to true mottling or apparent recovery. It therefore seems that the venation stage is a transitional stage of mosaic, and as far as external appearances go, it is in this stage that we find plant *b* in pl. 15, fig. 1. The plants shown in pl. 14 assumed a healthy appearance by the gradual darkening of all the spaces between the veins, while in the case of diseased leaves only some of the veins "run together," the area between others remaining chlorotic and the leaf becoming truly mottled. The histology of this has not been worked out satisfactorily, but "recovery" in strongly venated leaves seems to be effected by a lengthening of the palisade cells and a normal elongation and growth of the cells in general. In the chlorotic areas the palisade cells remain short, division is infrequent, and elongation of the cells in general is retarded. The relation of growth to the development of the disease is of great importance.

Another interesting observation on temperature relations is the following: Plate 15, fig. 2, shows a plant, the lowest shoot of which (*c*) is slightly mottled. The other shoots at the base (*a* and *b*) show no mottling whatever. Shoots *a* and *b* appeared during the time when the temperature of the greenhouse was low and sunlight was not abundant. Shoot *c* appeared during the early part of January when the temperature was higher and the illumination better. The plant was taken into the laboratory on January 10 to be photographed, and on account of the inclemency of the weather was allowed to remain there until January 13, when it was observed that some of the large leaves were becoming

chlorotic. The plant was therefore removed to the greenhouse in spite of the danger of freezing. On January 16, it was noticed that the plant had been severely chilled and that the edges of nearly all the leaves were turning black. The three shoots referred to above were removed, macerated in 5 cc. of distilled water, and the extract used for inoculations. The shoots weighed from 1.5 to 2 grams. Checks were run by inoculating plants with the juice of healthy tobacco plants and with sterile tap water. Ten plants were used in each case. No infections whatever occurred, and this is particularly significant since all extracts gave a strong oxidase reaction with guaiacum and hydrogen peroxide.

It would therefore seem that during the time which elapsed between the chilling of the plant and making the inoculations, the metabolism of the plant had been altered sufficiently to destroy the infective principle which the shoots originally contained. One can readily conceive of such an alteration, if we accept the enzymic theory as an explanation of the cause of the disease. The mottled shoots which had remained on the old stalk lost the sharp definition between lighter and darker areas, and the green shaded gradually into the lighter areas, the general position of which was marked by a yellowish brown spot. These results also show that the infective substance is not found in the tissue of normal plants.

Recovery from mosaic has been denied by many workers, and we are not in a position at this time to state that the experiments reported above demonstrate actual recovery. The failure of most workers to observe anything in the direction of recovery of diseased plants may probably be accounted for by the fact that the work on this phase of the problem has been rather limited. Some work in this direction has been done by liming the soil, etc., but no elaborate experiments have been performed. The work has furthermore been done under environmental conditions which favored the development of the disease. We may rest assured that when plants are grown under such conditions that the spontaneous appearance of the disease is favorable, recovery from the malady will be exceedingly rare. This applies particularly to greenhouse

conditions. Plants grown on plots or in the field mature and die or are cut down or killed by frost, which also precludes the possibility of observing total or apparent recovery.

Relation of Light to the Mosaic Disease

The effect of intensity of illumination or shading upon the development of the disease has been studied by Westerdijk ('10), Sturgis ('00), Chapman ('13), and others. A determination of the effect of colored light upon the mosaic disease of tobacco was attempted in the work of Lodewijks ('10) and more recently in the experiments of Chapman ('16). The work of Lodewijks, repeated by Chapman, is in brief as follows:

It was desired to note the effect of red and blue light upon the development of the mosaic disease. The tops of badly mottled plants were therefore covered with hoods made of red and blue cloth which were allowed to remain for about 30 days. At the end of this period it was noticed that shoots under red hoods were somewhat less mottled, while those under blue hoods showed little or no evidence of the disease.

It is very evident, however, that a red or a blue cloth hood does not give us a red or blue light, and all that can be expected in these cases is a difference in the shading effect of these hoods. In order to determine the effect of different light waves, it would be necessary to grow the plants under glass as nearly monochromatic as possible. The results reported by Lodewijks and Chapman are entirely in accord with what one would expect if plants were shaded. The red hood would shade the plants to a certain extent, growth and metabolic activity would be less than normal, and the disease would be less pronounced. The blue hood, however, would absorb more light than the red hood, the shading effect would therefore be greater, and the mottling would be reduced correspondingly.

The effect of light on the development of the disease is no meager problem. There are at least two distinct phases. It is a well-known fact that the mere absorption of light by

plants will raise their temperature from 4 to 11° C. above that of the surrounding atmosphere. The effect of light as regards increase in temperature is therefore important. Still more significant is the influence of light on the course of certain chemical reactions. Photosynthesis, for example, does not proceed in the absence of light. This, however, is an extremely complex and incompletely understood example, and the following illustration may serve to make the point clearer. When two volumes of chlorine are mixed with one volume of methane and the mixture exposed to strong sunlight, a violent explosion occurs, resulting in the formation of hydrochloric acid and the deposition of carbon, i. e., $CH_4 + 2Cl_2 = C + 4HCl$. If the mixture is kept in the dark or diffuse light, chlorine substitution products are formed, i. e., $CH_4 + Cl_2 = CH_3Cl + HCl$, $CH_3Cl + Cl_2 = CH_2Cl_2 + HCl$, etc. This simple experiment serves to show the importance of light stimulus in the determination of the direction of certain chemical reactions. Since light plays such an important rôle in the metabolic activities of green plants, its effect upon the manifestation of such a disturbance as the mosaic disease must be interpreted with the greatest reservation.

Transmission of the Mosaic Disease through the Seed

A great deal of dissension may be noted in the literature on the transmissibility of the mosaic disease through seed. The early appearance of mosaic, which may occur in the second leaf, has led certain workers to conclude that the disease must be carried over in the seed; yet, another sowing from the same sample of seed may yield plants which do not become diseased until they are half grown. Still greater confusion results when the idea is advanced that injury in transplanting predisposes the plants to the malady.

An attempt was made to throw further light upon this question, the method of growing plants in paper boxes as described above being adopted. About 1500 plants were handled in this manner. In some instances the tobacco seed was first sown in flats and then transplanted, while in other cases the

seed was planted directly in the boxes. No consistent results warranting a definite decision with respect to the transmission of the disease through the seed was obtained. Neither does it seem possible by the method employed that injury can be a very great factor, and it should therefore be regarded as incidental or disregarded entirely.

It has been the general experience of all workers that the seeds of diseased plants usually give rise to healthy plants, and this in itself is evidence strongly in favor of the non-transmissibility of the disease through seed. If we consider this question from the standpoint of an organism or parasite, one can only arrive at a satisfactory explanation by assuming that the virus present in the placenta (Allard, '15) cannot penetrate the integuments of the ovule and is thus filtered out. A much better explanation is afforded by the physiological aspect of the problem. In this case we should not expect to find the infective principle present in the seed. Mosaic is most pronounced in young shoots where growth, photosynthetic and metabolic activity is at its height. It is in these tissues that plant products are first formed. In the seed the physiological functions are entirely different. The relatively simple compounds elaborated in the green portion of the plant are polymerized there into storage products and no initial synthesis whatever occurs. The infective principle, if elaborated in young active shoots, may be transmitted to all parts of the plant through the general food stream and might therefore be present in the placenta. It might even enter the ovule, but on account of the specific functions of the ovule, embryo, and endosperm, the infective principle or corresponding enzyme might be altered and its continued formation obviated. We must bear in mind that in a problem of this kind we are dealing, from the standpoint of the host, with an extremely complex organism and must not confuse an intricate, nevertheless complete, chemical reaction or function exhibited by it with such a phenomenon as, for example, multiplication of bacteria or ultramicroscopic parasites. This will be discussed again later on.

THE INFECTIVE PRINCIPLE REGARDED AS AN ORGANISM

The work reported above was undertaken with the hope of obtaining information on the chemical or physiological nature of mosaic diseases. The problem was not, however, treated solely from this standpoint, but was undertaken in an unbiased attitude with the hope of gaining any possible information on all sides of the problem. A set of experiments was therefore planned which might bring out more clearly any relation of mosaic diseases to parasites or filterable organisms.

One method of attack was that of growing plants under sterile conditions. If plants grown under sterile conditions contracted the disease, the cultures otherwise remaining clean, one would, from a uniformity of results, be justified in concluding first, that the disease originated within the plant and that it is really of a metabolic or physiological nature, and second, that we have actually encompassed all physiological factors necessary for its production. If, on the other hand, no mosaic occurred, one would nevertheless not yet be justified in concluding that the disease must be due to an organism, since we are in the first place absolutely ignorant of the cause of the disease, and the physiological factors necessary for its production may be absent or subdued.

The cultures were prepared in the following manner: Jars (measuring 20 × 8 cm. and 16 × 10 cm.), specimen tubes (40 × 5 cm.), cylinders (48 × 5.5 cm. and 36 × 8 cm.), and tall specimen jars (varying in size from 40 × 11 cm. to about 60 × 16 cm.) were used. A certain amount of soil, the quantity varying with the size of the jar, was placed in each jar and a proportionate amount of water was added. All vessels, with the exception of the tall specimen jars, were sterilized for 4 hours at 15 pounds pressure. The latter were sterilized with formaldehyde, rinsed with sterile distilled water, and into them a certain amount of sterile soil was then placed. Soils from different sources were used, i. e., from the plot containing diseased plants and from greenhouse plots in which diseased material had been grown. Soils from the to-

bacco and cucumber plots were kept separately. The seed was treated in different ways. The commercial seed was sterilized with formaldehyde and a check was run against this with unsterilized seed. Seed was then collected from diseased tobacco and cucumber plants and applied in a sterile and non-sterile form to sterile and non-sterile vessels.

The necessity of growing plants which are to be used in physiological experiments under sterile conditions, has been recognized for some time, but comparatively little stress has been laid upon the desirability of employing sterile cultures of host plants in pathological work. When dealing with problems such as are encountered in the "physiological" diseases, methods like the above become quite essential. In order that contamination might be detected in the sterile cultures, about 5 to 10 cc. of ordinary potato agar was poured on top of the soil before planting the seed. The number of cultures totaled 352. The cultures were set up October 29 and 30, 1916, and allowed to run until January 10, 1917. At this time many of the plants had died, none of them, however, having shown the slightest indication of mosaic. The negative results obtained do not prove nor disprove anything, and this is particularly true, since the spontaneous occurrence of the disease was not observed anywhere in the greenhouse at that time of the year. The experiment will be repeated as soon as time permits.

Another line of attack on this phase of the problem was the detection of metabolic activity in a medium containing an extract of diseased plants. The technique involved, however, was more complicated than was originally supposed, and while no results are available at this time, it is hoped that the experiments outlined will prove of great value. If the infective principle is of the nature of an enzyme, we should expect a definite chemical reaction to occur which should be governed by the laws dominating chemical reactions. The speed of the reaction might be influenced by acidity or alkalinity, but there should be no change in the nature of the end product. If, on the other hand, the infective principle is of the nature of an organism, we should expect a relatively

simple constituent of the medium to be destroyed or used up in the metabolism of the organism. The organism should furthermore not be restricted to the use of a single compound as a source of food, but substitutions could be made. The metabolism would furthermore not be governed to the same extent nor in the same manner as are single chemical reactions, though it would undoubtedly be influenced by physiological relations much the same as are other organisms.

NEW AND RECENTLY DESCRIBED MOSAIC DISEASES

Although cucumber mosaic has been known for several years, its economic importance has not been appreciated until recently. Since the prevalence of the disease is only partially known, it is difficult to estimate the annual loss involved, but it undoubtedly approximates a million dollars annually. It is reported from an area bounded by Minnesota, Colorado, Mississippi, Virginia, and New York. The foliage of diseased plants always assumes the curled or crinkled and mottled appearance characteristic of mosaic diseases, while the fruit may remain small and cone-shaped, or become extremely "warted" and mottled, or only mottled and not greatly deformed as shown in pl. 16, fig. 1.

The new mosaic disease of peanuts has recently been described by McClintock ('17). But a single plant was found, and all inoculation experiments gave negative results. On account of shortage of material with which to carry on extensive inoculation experiments, it was impossible to establish definitely the identity of the disease.

A disease appearing spontaneously on avocado plants[1] grown in the greenhouse for experimental purposes, showed all the characteristics of mosaic diseases. So far as can be ascertained by the writer, no observations of this kind have ever been made. The plants were grown in a room together with diseased tobacco plants, and it is therefore impossible to state whether the disease was contracted from the tobacco or whether it is distinctive of the avocado. The plants are

[1] The seeds for these plants were obtained from Santa Anna, California, through the courtesy of W. S. Reeves.

now being used in connection with physiological experiments, and want of material has precluded carrying on inoculation experiments, though this will be done as soon as possible. Plate 17 shows the healthy and diseased avocado plants.

Discussion of Recent Investigations

Whether or not mosaic diseases are initially "physiological" or are caused by an organism, it is nevertheless apparent from the preliminary results on physiological relations reported above that the physiological side of the problem is an extremely important one. After the physiological relations are more clearly understood, we will undoubtedly be able to account more fully for some of the inconsistencies of results, such as failure to get infection after inoculation or the spontaneous occurrence of diseased plants among checks. This is true regardless of the origin of the disease. Since so little is known concerning "physiological" diseases, it is impossible to cite conclusive data as regards environmental influences exerted on their causes.

In the case of diseases which have been proven to be due to well-described organisms, we are able to correlate the effects of environmental factors with something tangible and the results are always obvious. In any event, such problems must be considered from two different aspects, i. e., from the standpoint of the host and from the standpoint of the parasite. Work on temperature and host relations, covering a period of several years, has recently been reported by Gilman ('16). Our present knowledge on the subject has been admirably summarized by him. The importance of physiological pathology has also been brought out by the work of Selby ('99), Orton ('13), Halsted ('98), Balls ('08), Reed ('10), Earle ('02), and others. If mosaic diseases are caused by an organism, the effect of those climatic conditions favorable for their manifestation may be accounted for, first, by the favorable effect exerted upon the organism, and second, by the favorable effect on the host which, however, makes it better prey for the parasite. If, on the other hand, mosaic diseases

are "physiological" in origin, then any physical condition which would accelerate a particular type of chemical reaction would tend to make the disease more pronounced.

It was not until July, 1916, that any experiments were reported on the properties of the infective principle of mosaic diseases. Allard ('16[a]) at this time reported on a set of experiments which he interpreted as further evidence in favor of his view that mosaic diseases are due to a filterable parasite or "virus." His results are in brief as follows:

A number of filtration experiments were carried on, from the results of which Allard concluded that the organism was filtered out. These results can, however, be explained on an entirely different basis. Lacking a Berkefeld filter, he filtered the extract through a Livingston atmometer porous cup. It was found that the resulting filtrate contained no infectious substance. Although one might conclude that if an organism had been present, it was filtered off, it nevertheless does not preclude the possibility that a colloidal compound or enzyme, because of its relatively large particles or partial absorptive phenomena, might not also have been arrested by the filter. The extract was next filtered through powdered talc. It was found that if a certain amount of extract was filtered through a certain amount of talc, a stage was reached at which all of the infectious properties were filtered off. However, on studying the data, we notice that the oxidase activity was also destroyed entirely or reduced correspondingly. This should therefore not be interpreted as a simple filtration experiment with an organism, but as an illustration of the high absorptive properties possessed by colloids in general and therefore by enzymes, such as the oxidases and probably the infective principle of mosaic diseases.

Precipitation experiments with ethyl alcohol were also carried out by Allard. For this purpose 45, 50, 75, and 80 per cent alcohols were used. In each case a certain amount of extract was taken and enough absolute alcohol added to give the desired concentration. The mixture was allowed to stand from 1 to 2 days, at the end of which time the precipitate was filtered off and dried at room temperature. Suspensions of

this were then used for inoculations. The precipitates obtained with 45 and 50 per cent alcohol produced the disease, while those obtained with 75 and 80 per cent alcohol gave negative results. Any one familiar with the preparation of enzymes is conscious of the fact that the higher concentrations of alcohol destroy most enzymes in a comparatively short time, and this is probably what happened when Allard treated his material with alcohol for 2 days. Dilute concentrations of alcohol do not exert a deleterious action, and 20 to 30 per cent is therefore often used during the process of extraction in order to prevent bacterial action. The results of Allard should, therefore, not be interpreted as proof of the destruction of the mosaic organism by higher concentrations of alcohol, but rather to illustrate the deleterious effect which high concentrations of alcohol exert on enzymes such as the infective principle of mosaic diseases.

Extracts were next treated with hydrogen peroxide in order to destroy the oxidases. A concentration was found at which all oxidases were destroyed, but the infective principle was retained. It was this method which enabled Allard to demonstrate that mosaic diseases are not caused by oxidases. The problem was then attacked from the other angle and the infective principle was destroyed while the oxidases were retained. This was accomplished by adding different concentrations of formaldehyde. When concentrations of formaldehyde of 1:800 and 1:1000 were employed, only 1 plant out of 10 became infected. When greater concentrations were used no infections resulted, while with greater dilutions the infectious properties were retained to a considerable degree. Although not specifically stated by Allard, this was presumably interpreted to mean that formaldehyde was penetrating enough to kill the organism. On the other hand, it suggests a specificity of reaction of a compound with formaldehyde, and probably with aldehydes in general. Furthermore, if formaldehyde is one of the first products of photosynthesis, as contended by Usher and Priestley ('06, '06[a]), Schryver ('10), and others, one can easily conceive of a physiological origin of mosaic diseases. There is less carbohydrate in the

lighter areas of diseased leaves than in the darker. If the metabolism of the cells of the lighter areas is such as to arrest the formation of formaldehyde, the formation of unusual enzymes might take place which, when introduced into a normal healthy individual, are capable of reproducing themselves and stimulating a pathological condition in a manner which will be described later.

Dried and ground mosaic material was next treated with various organic extractives. Ten grams of dried material were treated with 70 cc. of the extractive for 2 days. At the end of this time the extractive was filtered off and evaporated at room temperature. Inoculations were later made with water suspensions of the residue obtained after the evaporation of the extractive, and also with water extracts of the material which had previously been treated with the extractives. The extractives used were ether, chloroform, carbon tetrachloride, toluene, acetone, ethyl alcohol, methyl alcohol, and glycerin. No infections (with one exception) resulted when inoculations were made with the water suspension of the residue obtained after the evaporation of the extractive. This exception was that of glycerin. In this case, however, the residue had been macerated with the extractive, and Allard later found that if the glycerin was simply allowed to act on the dried mosaic material and was then poured off, it contained little, if any, of the infectious principle. When inoculations were made with the water extract obtained from material which had been previously treated with various extractives, infections resulted in all cases except in those where alcohol had been used.

All this is entirely in accord with what one would expect if we were dealing with an enzyme. If the infectious substances were of the nature of an organism, it certainly should have been destroyed by treatment for 2 days with concentrated solutions of such antiseptics as ether, chloroform, carbon tetrachloride, acetone, toluene, and glycerin. It also lends further proof to the contention that in the case of treatment with formaldehyde the destruction of the infectious substance was due, not to the antiseptic properties of formaldehyde, but

was the result of a chemical reaction; and the reason for the destruction of the infective principle at a concentration of 1:800 is that it required this quantity of formaldehyde to balance the reaction. Glycerin, in varying concentrations, is frequently used as an extractive for enzymes. The solution of the enzyme actually takes place in the water, but the use of glycerin is advantageous on account of its penetrating power and preservative properties.

The other extractives employed by Allard, when used in connection with enzyme work, are used only as preservatives. The fact that the infective principle can be extracted only with water is in accordance with the common practice of securing enzymes by dissolving them in water or obtaining them as aqueous extracts. The action of the alcohol on the dried material was two-fold. In the first place, it had a tendency to precipitate the enzyme in the tissue, thus making subsequent extraction impossible, and in the second place, the alcohol exerted a destructive influence upon the enzyme.

Allard also treated green tissue with extractives. In these cases he was able to extract the infective principle at least to some degree. However, this should be regarded as a solution of the enzyme in the water naturally present in the plant, the extractives merely acting as antiseptics.

It was also found that the "virus" could be thrown out of suspension with precipitates of aluminium hydroxide and nickel hydroxide. This merely demonstrates the familiar process of flocking out colloidal suspensions and is entirely applicable to enzyme solutions.

The effect of heat was tested on both wet and dry material. Extracts, according to the results of early workers, lose their infectious properties at 65–75° C. Although this is the lethal temperature for many organisms, it is also the temperature at which most enzymes are deactivated. Allard states that "the infective principle of the virus is quickly and permanently destroyed at temperatures near the boiling point. . . ." This is not only applicable to enzymes but also to other compounds readily undergoing hydrolysis. Dried heat destroyed the infective principle of dry material at 130° C., but Allard's

data show that oxidase activity was also destroyed at this point. A temperature of —180° C. did not destroy the "virus." Although some organisms can withstand a temperature as low as this, it is also a fact that chemical compounds, including enzymes, can be cooled to any degree without changing their constitution.

Various workers have found that fermented extracts of mosaic material gradually lose their infectious properties. This has also been experienced by the writer. Allard ('16[a]), on the other hand, states "that the virus will retain its infectious properties almost indefinitely without the addition of toluene. With no preservative whatever added, the bottled virus was highly infectious when tested 12 to 15 months later, although putrefaction had taken place." We are not in a position to discuss this matter at this time since we are absolutely ignorant of the cause of this putrefaction. It might have been due to the action of bacteria, of wild yeasts or fungi, or the activity of autolytic enzymes present in the extract. On the other hand, if the infective principle is as sensitive to formaldehyde as Allard's results indicate, the destruction of the infectious properties might have been due to the formaldehyde resulting from the oxidative decomposition of chlorophyll (Warner, '14). The extracts are preserved as aqueous solution, generally using toluene as a preservative. This is exactly the manner in which enzyme digestion mixtures are set up, which is further indication that when putting up an extract of mosaic material in this manner, we are preserving an enzyme and not an organism.

Considerable disagreement may be noticed in the literature as regards the transmissibility of the mosaic disease of certain plants to other species. Some of the work on this phase of the problem is reviewed briefly in a recent article by Allard ('16[b]), and results are reported which indicate that the mosaic disease of *Nicotiana viscosum* is distinct from that of *Nicotiana tabacum*. These results might lead one to conclude that these are "biological species" or "physiological races" of the mosaic "virus." However, it is a well-known fact, particularly in animal physiology, that fluids,

toxins, or enzymes from one species may not affect closely related species. The constitutional or physiological differences between two species make these organisms two different species, and the ability of certain plants to resist the influence of certain mosaic extracts can be accounted for on physiological grounds. It is the physiological difference between hosts which makes some of them immune to a disease while others are susceptible, and it is likewise a physiological difference among parasites which makes "physiological races" *physiological* races. The term is used primarily in connection with the parasitism of rusts, mildews, etc., which may be detected with the naked eye and are adequately described. The term should not be used in connection with the infective principle of mosaic diseases which has never been seen, never been described, and the "properties" of which are only partially known. If the term is used at all it should be used only as a matter of convenience, and this is discouraged since it tends to lead to confusion.

From the above it is obvious that when injecting the infective substance obtained from a diseased plant into a healthy plant, we are handling an enzyme and not an organism. Although nothing is known as regards the nature of this enzyme, it is probably, judging from its reaction with formaldehyde, of the nature of an aldehydase. If formaldehyde is one of the first products of photosynthesis, one can easily conceive of a physiological origin of mosaic diseases. A probable relation with photosynthesis is furthermore brought out by the observation on the carbohydrate content of the lighter and darker areas of diseased leaves, as was pointed out in the microchemical work reported above. The problem has, in the light of these facts, assumed a somewhat different aspect. Although nothing is known as to the nature of the enzyme, the main issue of the problem is this: How does this enzyme originate and what are the factors which induce its formation? As was pointed out by the writer earlier in this paper, and as has also been shown by Allard, this infective principle is not found, at least in active form, in healthy plants grown under normal conditions. If it is

present, inhibitory factors are also present which hold it in check, determine its reactions, and do not allow it to be formed to such an extent as to exert pathological influences. It is of course true that we have no basis for assuming that this supposed enzyme is the initial cause of the disease, and may be considered by some as a result of the disorder, but we are nevertheless forced to the conclusion that when this supposed enzyme is injected in an active form into healthy plants, it is capable of stimulating its further production, and therefore we have reason to believe that it is the causal agent in all cases. The physiological conditions which determine its production form the nucleus of another problem.

A point which may seem to be greatly in favor of the "virus" theory is that the extract may be diluted 1:1000 or even 1:10,000 and still retain the capacity of inducing the disease in healthy plants. It is a well-known fact, however, that nearly all chemical reactions reach their termination better and more completely when the chemicals are brought together in *relatively* dilute concentrations. This is particularly applicable to substances of a colloidal nature. Chemical reactions resulting from the activity of such colloidal compounds as enzymes, are largely dependent upon the adsorptive power of these enzymes. If, then, they are present in relatively dilute concentrations, the colloidal particles will be more dispersed, the opportunity for adsorptive phenomena greater, and chemical action free to proceed in its normal course. If the enzyme producing mosaic diseases is extremely active, one may easily understand how great dilution would yet enable it to induce metabolic disturbances. When reactions of this kind are carried on *in vitro,* the activity, on account of a limited amount of material, will ultimately cease. In a living organism, however, the situation is entirely different. More compounds are constantly being formed as the result of metabolic activity. When these compounds are acted upon by the enzymes, the end products or the intermediate products formed may stimulate the formation of more of the enzyme, which in turn will lead to further disturbances.

This may be hard to understand, but that similar phenomena do occur is an established fact. It has been demonstrated in animal physiology as well as in plant physiology. Abderhalden and his co-workers have found that if, for example, native protein, proteoses, or peptones are introduced parentally into an organism, enzymes normally not present in the blood will be formed (Underhill, '15). The proteolytic enzymes produced hydrolyze the compounds to amino acids which are then absorbed from the blood stream by the tissues. When hydrolysis of the compounds has been completed, the enzymes disappear again, but will be reformed upon the injection of more of the proteinaceous substances. Knudson ('13) found that tannase is not produced by *Aspergillus niger* nor by certain species of *Penicillium* if tannic acid or its decomposition product, gallic acid, is omitted from the nutrient solution. The amount of tannase produced increases in accordance with the concentration of the acids. Many other examples might be cited, all of them illustrating the same point.

If the mosaic enzyme acts upon a compound present in the healthy plant, or if in the process of photosynthesis it determines the formation of certain compounds, we can easily conceive how the presence of some of the end products or intermediate products may stimulate the formation of more of the enzyme. We must remember that after the enzyme has once been introduced into the plant, it plays a part in, and in fact becomes a part of, the metabolism of the plant. This fact becomes obvious when we consider the malformations and the large amount of "infective principle" that the substance gives rise to when injected into normal plants.

These interpretations are entirely in accord with the fundamental principles upon which all our scientific conceptions in pathology and biology are based. The continued formation of the mosaic enzyme when once introduced into a healthy plant has been accounted for on purely physiological grounds. It is of course true that self-reproduction is a characteristic of living things, but this must not be confused with the reproduction of chemical compounds, including enzymes, in a highly

developed and complex organism. The ability to produce these compounds according to the needs of the organism has been demonstrated by the work of Abderhalden and his collaborators, by Knudson, and others. We cannot compare the functions of a complex organism, such as the ability to produce certain compounds in accordance with its need for them, or the ability to determine the course of extremely complex, yet complete, chemical reactions, with a function which the organism can perform only as an entity, such as self-reproduction. We furthermore must not confuse "self-reproduction" in comparatively simple organisms, like the bacteria, with the production and reproduction of enzymes in the higher plants and animals. It is likewise true that many infectious diseases are associated with parasitism, but there are many which have not found an explanation in this cause. Examples of this in animals are measles, chicken-pox, mumps, scarlet fever, etc., while the group of "physiological diseases" of plants serves as an example for the vegetable kingdom.

The fact that self-reproduction in a simple organism and the production of certain substances in a complex organism are two entirely different things is furthermore demonstrated by the following example. We are all familiar with the fact that the pathological condition characterizing diphtheria is attributable to the toxin produced by *Bacillus diphtheriae* which has lodged itself in the pharyngeal passages. If a portion of the toxin is injected into a normal individual, he will succumb to the pathological condition, i.e., lesions of the heart, nerves, kidneys, etc., characteristic of diphtheria, and additional toxin will be produced in his system; yet no organism has entered into the case. The inflamed condition of the throat will, of course, be absent, but this is largely the result of local irritation. Similar reactions occur in the production of serums, anti-bodies, and the like in other diseases, and it is upon the ability of an organism to produce and reproduce such complex substances and enzymes that the science of immunology is based.

It is unfortunate that we have to go to the field of animal pathology for examples of this sort, but we are forced to do

so because of the complexity of these reactions and, furthermore, because of our ignorance of such things in the vegetable kingdom. The writer does not wish it to be thought that in drawing upon animal pathology for examples, an opportunity is sought for begging the question of the production of the mosaic enzyme in infected plants. It merely serves to illustrate the fact that the production of the mosaic enzyme is no more complex than the production of toxins, serums, and the like in animal pathology, all of which are accounted for on physiological grounds.

In the light of all evidence now at hand, we must consider the infective principle of mosaic diseases as being an enzyme, and in doing so we do not abuse any of our fundamental biological conceptions of pathology and physiology.

Summary

The evidence that has accumulated from the efforts of recent workers on mosaic diseases and that presented in this paper enable us to formulate the following summary:

1. Mosaic diseases are not caused by an unbalanced inorganic nutrition. The inorganic elements are present in diseased and healthy tissue in relatively the same amounts.
2. Carbohydrates are more abundant in the dark green than in the light green areas, regardless of the time of day.
3. Proteins are present in both the lighter and darker areas. Preliminary nitrogen analyses indicate that the quantity of protein in the lighter areas is slightly in excess of that in the darker areas.
4. Whether or not the disease is initially due to physiological disturbances or to parasites, the physiological phase is an extremely important one.
5. Preliminary observations on temperature relations indicate that there is not only an optimum for the manifestation of the disease, but also a maximum and minimum above and below which the disease is checked. The

development of the disease is arrested sufficiently to suggest apparent recovery.

6. Properties of the infective principle substantiate the view that the infectious substance is an enzyme and not a "virus." This enzyme is not of the nature of the oxidases giving the guaiacum reaction.

7. The infective principle is greatly adsorbed by talc, a phenomenon characteristic of all colloidal compounds including enzymes.

8. There is a specificity of reaction between the infective principle or mosaic enzyme and formaldehyde and probably with aldehydes in general.

9. The destruction of the infective principle cannot be attributed to the antiseptic properties of formaldehyde, since treatment with concentrated solutions of the best antiseptics as ether, chloroform, carbon tetrachloride, toluene, acetone, and glycerin does not destroy the infectious properties.

10. The infectious properties are destroyed by concentrations of alcohol which are destructive to enzymes.

11. The temperatures which destroy the infectious properties are the same as those which inactive enzymes or hydrolyze some organic compounds. Cooling has no greater effect on such properties than is exerted on any chemical compound, including enzymes.

12. The reproduction of the mosaic enzyme can be accounted for on purely physiological grounds, but the factors which originally induced its formation are still unknown.

13. The specificity of reaction of the mosaic enzyme with formaldehyde and the unbalanced carbohydrate relation between lighter and darker areas, combined with the contention that formaldehyde is one of the first products of photosynthesis, suggest a basis upon which the physiological nature of mosaic diseases may be explained.

14. The continued production of the mosaic enzyme in inoculated plants is in accord with the fundamental principles of pathology and physiology.

In conclusion the writer wishes to express his indebtedness to Dr. G. T. Moore and the Missouri Botanical Garden for generously providing facilities with which to prosecute the problem, and also, to thank Dr. B. M. Duggar for numerous suggestions and helpful criticisms.

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EXPLANATION OF PLATE

PLATE 14

Fig. 1. Effect of low temperature (45° F.) upon the development of the mosaic disease of tobacco: *a*, old leaf still showing mosaic; *b*, young leaf showing very slight venation at the tip, but otherwise normal; *c*, older leaf showing slight venation, but no mottling.

Fig. 2. Effect of high temperature (85° F.) upon the development of the mosaic disease of tobacco: *a*, young leaf showing venation; *b*, older leaf showing venation changing to mottling; *c*, old leaf showing mottling. This leaf is about the same age as leaf *c* in fig. 1.

Fig. 3. Showing change from venation to mottling, temperature 85° F.: *a*, some venation still present in tip of leaf, but otherwise mottled; *b*, younger leaf venated throughout.

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FREIBERG—MOSAIC DISEASES

EXPLANATION OF PLATE

PLATE 15

Fig. 1. Effect of temperature on the development of the mosaic disease of tobacco. Plants *b* and *c*, grown at a temperature of 65–75° F., are the same age. Plant *b* is apparently affected with mosaic, while *c* is perfectly normal; photographed November 24, 1916. Plant *a* shows *b* on December 13, 1916, after having been kept at a temperature of about 40° F. and illustrates apparent recovery.

Fig. 2. An old diseased plant transferred to the greenhouse in the fall. Shoots *a* and *b* appeared while the temperature was low (about 40–45° F.) and illumination poor, and do not show mottling. Shoot *c* appeared while the temperature was high (about 60–70° F.) and sunlight more abundant. Slight mottling is evident.

FREIBERG—MOSAIC DISEASES

EXPLANATION OF PLATE

PLATE 16

Fig. 1. Mosaic disease of cucumber.

Fig. 2. Mosaic disease of tobacco.

Fig. 3. Mosaic disease of citron.

1

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3

FREIBERG—MOSAIC DISEASES

EXPLANATION OF PLATE

PLATE 17

Figs. 1 and 2. Mosaic disease of avocado.

Fig. 3. Diseased and healthy avocado plants; seed planted November 1, 1916; photographed March 28, 1917.

FREIBERG—MOSAIC DISEASES